Operating Manual

for

2501/2/3AH

Power Analysis Instruments

Xitron Technologies Inc.

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1. INTRODUCTION

Congratulations on purchasing the latest in high technology power analysis instruments from Xitron Technologies. This family of instruments offer the highest of accuracies in combination with a vast array of measurement analysis capabilities.

As additional features are added to the impressive list of capabilities, this manual is currently undergoing modifications and will be updated periodically. This document will guide you through basic front panel operation and digital control of the 2503AH instrument family (including the 2501AH, 2502AH and 2503AH)., Please contact the factory at (619) 458-9852 if you require any assistance.

This manual is released January 14, 1994.. All recepients of this document will receive manual updates free of charge until June 30, 1994. Please register your name and mailing address with Xitron Technologies if you wish to receive these manual updates.

2. 2503AH MANUAL OPERATION

This manual addresses manual and computer based operation. This section deals with manual (front panel based) operation, while section 3 addresses digital interfacing via IEEE-488 and RS-232 ports. It is recommended to study this section, even if you are planning to control the instrument by computer. The features and functional characteristics of the 2503AH power analyzer family are discussed in the context of operating the instrument via the front panel.

2.1. FRONT PANEL BASICS

Before configuring the instrument for your application and making measurements you should be aware of several aspects of general instrument operation.

2.1.1 Channels

The 2503AH family contains one (2501AH), two (2502AH) or three (2503AH) measurement channels, which may be either used independently, or any two or three of these channels may be used synchronously. Each measurement channel contains a voltage measurement input and a current measurement input, which always have their amplitudes measured synchronously.

This family of instruments offer the unique capability of synchronously measuring amplitudes on any 'group' of channels, while independently measuring each input's frequency content, and automatically selecting one of these frequency measurements as the synchronization source for the 'group' amplitude measurements. This may sound complicated, but it really isn't! All the user does is select the inputs within a 'group' which are allowed to measure the fundamental frequency, the instrument does the rest automatically!

2.1.2 Lowest Fundamental Frequency

These instruments offer measurement capabilities from 0.0001Hz (a period of 10000 seconds, or almost 3 hours!) to over 500KHz (a period of only 2%s). In order for the instrument to make "timely" decisions regarding changing ranges and signal presence detection, some knowledge of the expected lowest frequency is required. In various configuration menus there is reference to this data. The user should select a frequency below which there is known to be little (less than 5% of range) signal content other than DC. Generally a figure of 40Hz is suitable for most line measurements, while a selection of 1KHz for high frequency signals offers considerable timesaving during autoranging. Under some circumstances it may be found that the instruments' autoranging forms a oscillatory combination with some active loads or sources, in these cases reducing the lowest fundamental frequency to below the frequency of oscillation will provide a solution.

2.1.3 Menus

Front panel operation is achieved through the use of user interactive menus on the front panel display. Menus are initiated by the user pressing one of the primary front panel keys (e.g. QUICK and SYSTEM).

Many menus offer more selections than can be displayed on a single screen, in these cases the user can use the arrow keys (located near the display) to scroll the display upwards and downwards through the available selections. The user can change any of the displayed selections by pressing the SELECT key for the display line containing the information to be changed. In some cases a line may contain several editable items, in this case the SELECT key or the LEFT/RIGHT arrow keys can be used to select the item to be changed. In all cases, a flashing 'block' cursor is positioned within the item presently selected to be edited. The edit is completed by pressing the ENTER key.

Multiple choice selections are changed by using the UP and DOWN arrow keys to display the desired selection and then pressing the ENTER key. When only one editable, multiple choice, item resides within the display line, the SELECT key is used to change the selection. Measurement channel selection choices also allow the use of the 1 (ChA), 2 (ChB) and 3 (ChC) keys as 'shortcut' selections.

Integer numeric entries may be selected by using the UP/DOWN arrow keys to modify the displayed data, or by using the numeric keys directly. The displayed data is saved, and the edit terminated, when the ENTER key is pressed. The CLEAR key sets the displayed number to zero (except in cases where zero is invalid, when it is set to the factory default value), the first numeric keypress automatically clears and sets it to the entered number.

Non-integer (i.e. containing a decimal point) numeric entries may be selected by using the numeric keys, decimal point key and polarity keys. The displayed data is saved, and the edit terminated, when the ENTER key is pressed. The CLEAR key sets the displayed number to zero, the first numeric keypress automatically clears and sets it to the entered number.

All changes made within the menu are stored until the user saves these by pressing the ENTER key while no item is selected to be edited. Many menus have a heading line (in uppercase characters), in which case the menu may be terminated by pressing the SELECT 1 key (next to the heading line). Pressing the CLEAR key while no selection is being edited, generally causes the selections made to be discarded and the menu to be terminated.

Most menus offer a complete method the configure the desired aspect of the instrument. Operation of these menus may be 'suspended' and another menu operated by simply pressing the other menu's primary access key. In this case the user is returned to the original menu when this second menu has been completed. This offers the user the ability to make adjustments to the instrument's operation in one area while changing another.

2.2. QUICK START

The 'quick start' menu allows the majority of users to configure the instrument for the desired application without having to select any application details.

All the user needs for 'quick start' selection is the lowest frequency likely to be encountered (other than DC), and the general description of the application. The applications supported with a menu choice (selected on the second line of the display) are illustrated in this section. Since applications may be added from time to time, this manual may not cover the latest additions, nor are special instrument configurations included.

The procedure for selecting the desired "quick start" option is as follows :

Press the QUICK key.

If the line fundamental frequency is not in the range 40Hz to 4KHz, press the SELECT 2 key and enter the lowest fundamental line frequency expected (press the ENTER key to complete this selection).

Press the SELECT 3 key to obtain a cursor in the third display line.

Repeatedly press (or hold down) the UP arrow key until the desired "quick start" option is displayed.

Press the ENTER key twice.

The instrument is now configured for the measurement of your selected application, if any "fine details" require modification then refer to the additional configuration information later in this document.

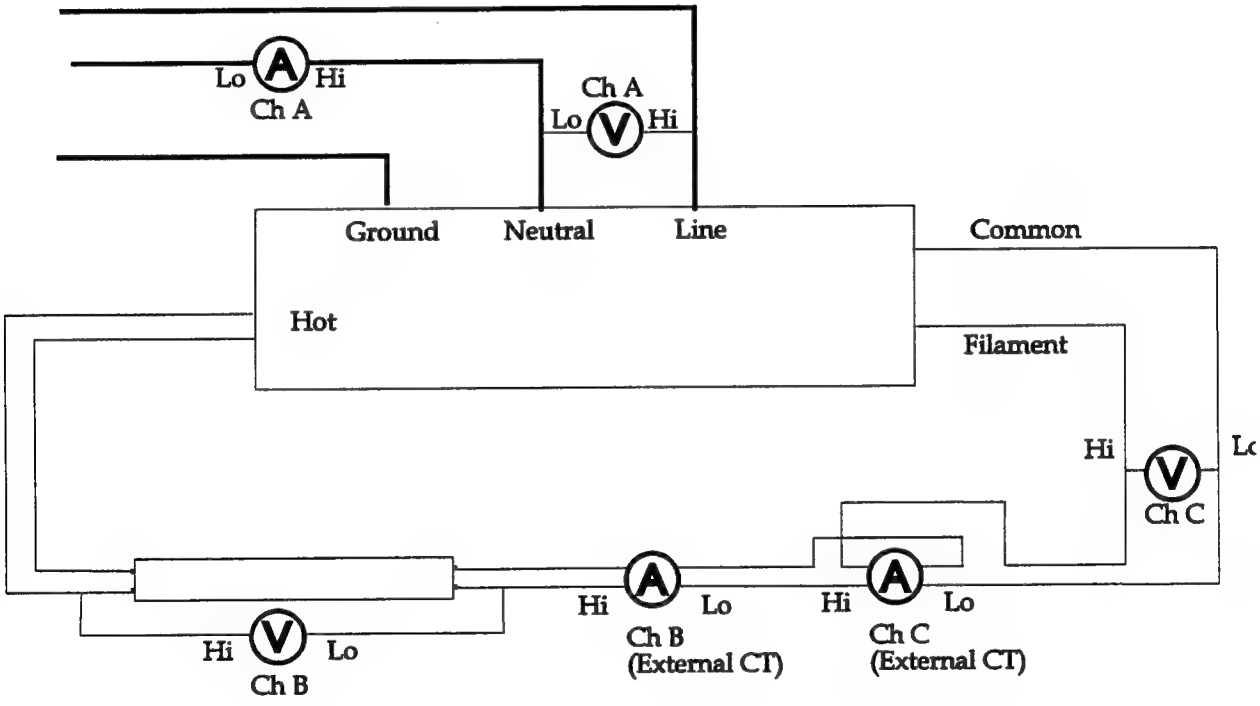
The third (lowermost) line in this menu allows the user to completely clear any defined display parameter lines.

2.2.1 "Independent Channels".

This configures the instrument for independent (asynchronous) measurements on each channel. This selection covers all applications where 'inter-channel' phase related measurements are not required. All channels are configured to measure signals having a fundamental frequency in the range from the selected lowest frequency up to 100:1 above this. Individual channels may be altered using the methods outlined later in this document. Since there are many variations in independent channel configuration, no illustration is provided.

2.2.2 "A:Line In-BC:HF Out (Electronic Ballast Test) ".

This configures the instrument for the measurement of HF output electronic lighting ballasts, switch-mode power supplies, motor drives etc.. In this case, channel A is configured for measurement of line frequencies extending from the selected lowest frequency to 100:1 above this. Channels B and C (2503AH only) are configured for measurement of high frequency signals having a fundamental frequency in the range 5KHz to 640KHz. The line frequency channel is designated as an input measurement, and the high frequency channel(s) is/are designated as output measurements, thus measurements of power loss and efficiency are available following selection of the configuration. Usually there is no further configuration required following selection of this "quick start" option.



This is one possible way to measure a ballast and lamp.

Ch A will give Ballast volts, current, power, power factor, harmonics etc.

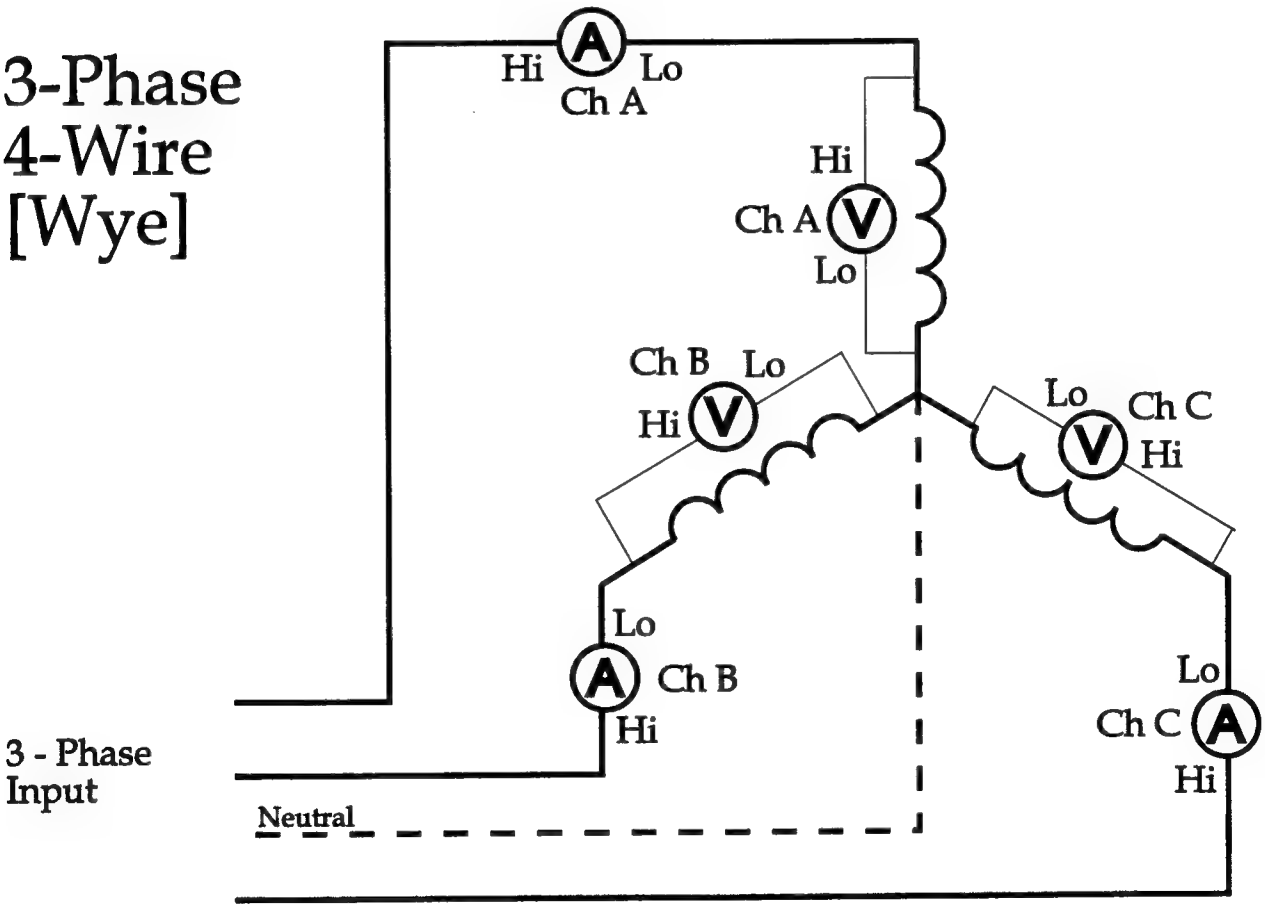
Ch B will give lamp voltage, total current, crest factor, etc.

Ch C will give filament voltage, current, power etc.

Meter will calculate total power (Ch A) minus lamp power (Ch B) plus filament power (Ch C) to give total efficiency / loss for the ballast.

2.2.3 "ABC: 3-Phase 4-Wire".

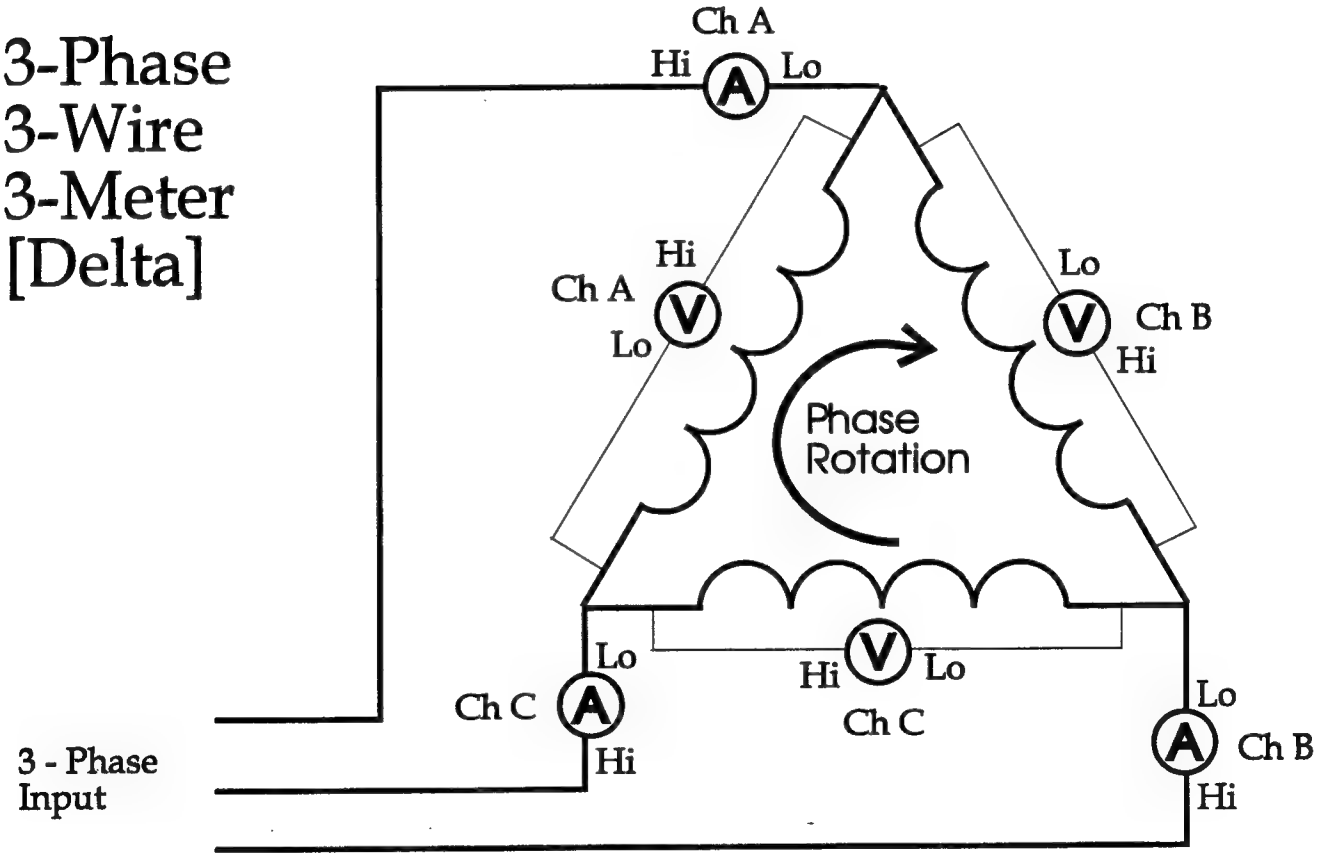
This configures the instrument for the synchronous measurement of 3-phase 'wye' power having a fundamental frequency extending from the selected lowest frequency to 100:1 above this. Filtering of the input signal is automatically selected at 1000:1 above the selected lowest frequency. This "quick start" option covers line frequency, low frequency (e.g. low speed motor drives) and high frequency 3-phase "wye" applications. The synchronization source (i.e. the measurement of the fundamental frequency) is selected as any channels' voltage or current input, the instrument will automatically select the most suitable input to act as the source of this data, and will automatically change this selection should a signal significantly change. This enables its' use on switch-mode motor drives, where the voltage waveform is a composite of both low and high frequencies.



Quick Start : ABC: 3-PHASE 4-WIRE

2.2.4 "ABC: 3-Phase 3-Wire (3 meter Delta)".

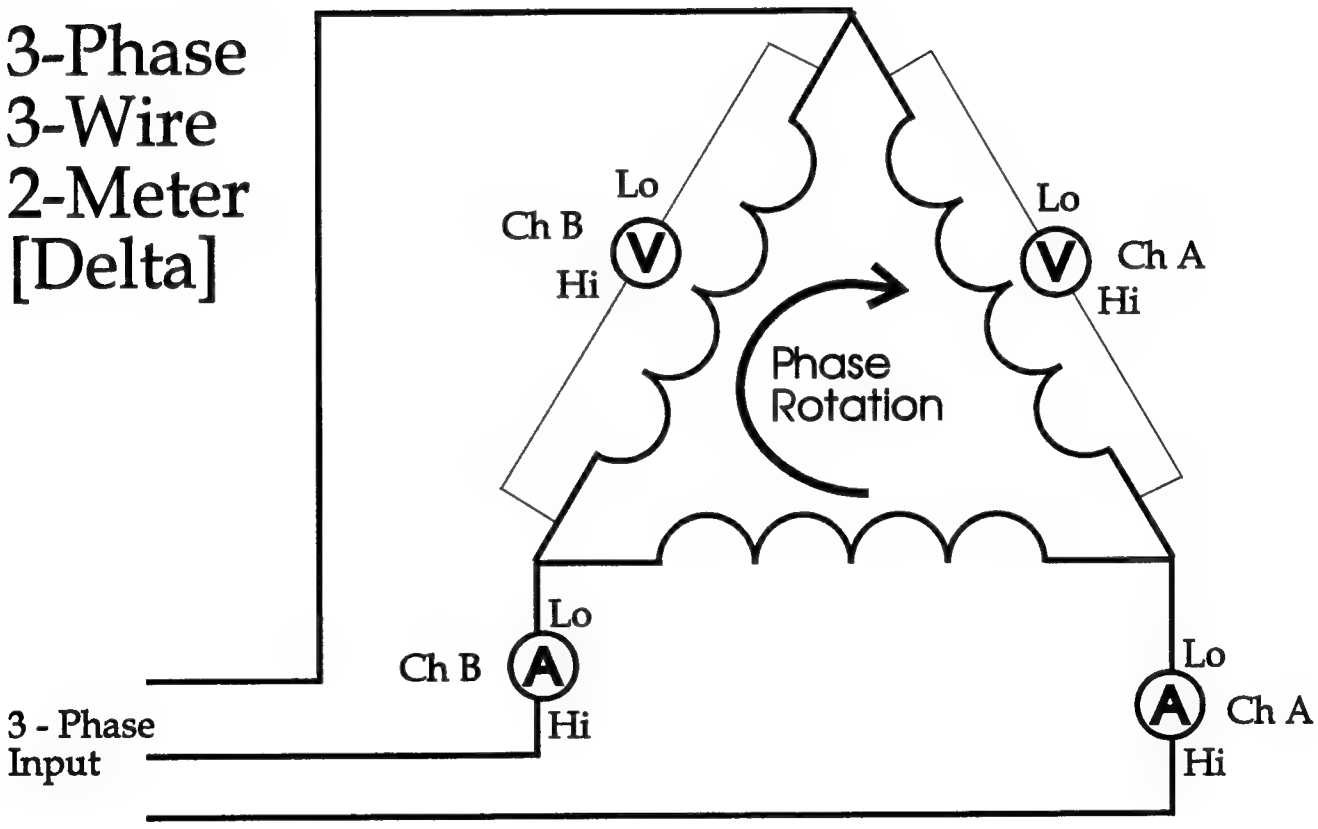
This configures the instrument for the synchronous measurement of 3-phase 'delta' power having a fundamental frequency extending from the selected lowest frequency to 100:1 above this, using all three channels of a 2503AH. Filtering of the input signal is automatically selected at 1000:1 above the selected lowest frequency. The channels should be connected as described in figure A for optimum performance at low power factors and/or unbalanced loads. In all other respects this configuration is similar to the "3-Phase 4-Wire" selection described above.



Quick Start : ABC: 3-PHASE 3-WIRE

2.2.5 "AB: 3-Phase 3-Wire (2 meter Delta)".

This is similar to the 3-channel 3-Phase 3-Wire selection described above, but only uses two channels (A and B). These two channels should be connected as described in figure B, note that the phase rotation of the channels must be opposite each other, and that each current measurements must be made in the line phase connected to the corresponding voltage HI terminal.



Quick Start : AB: 3-PHASE 3-WIRE

2.3. Displaying Data

The instrument can "hold" a list of up to 50 different data to display, the user scrolls through this list by using the UP and DOWN arrow keys. Each data in this list can be one of the following :

2.3.1 A measured parameter.

The measured parameter may be filtered individually for each display line, and may have it's basic unit converted into an alternative unit as desired. This is the normally used display data selection.

2.3.2 The difference between a parameter and another parameter or constant.

The instrument displays the difference between a measured parameter and a constant or the value of a measured parameter (either continuously updated or fixed to that measured at a particular time). The computed difference may be filtered individually for each display line, and may have it's basic unit converted into an alternative unit as desired. This is useful for displaying the variance of a measured parameter from a 'nominal' value.

2.3.3 The ratio, between a parameter and another parameter or constant

The instrument displays the ratio between a measured parameter and a constant or the value of a measured parameter (either continuously updated or fixed to that measured at a particular time). The computed ratio may be filtered individually for each display line, and may have it's basic unit converted into an alternative unit as desired. This is useful for displaying the ratio between a measured parameter and either a 'nominal' value or the value of another parameter (e.g. ratio between power supply input and output voltages).

2.3.4 Ratio difference, between a parameter and a constant or another parameter

The display line will show the difference between the ratio between a measured parameter and a constant or the value of a measured parameter (either continuously updated or fixed to that measured at a particular time) and unity. The computed ratio difference may be filtered individually for each display line, and may have it's basic unit converted into an alternative unit as desired. This is useful for displaying the variance of the ratio between a measured parameter and either a 'nominal' value or the value of another parameter.

2.3.5 HIGH/PASS/LOW limit comparison

A HIGH/PASS/LOW limits comparison of a measured parameter against a constant or variable nominal value, using a constant "limit range'. The measured parameter may be filtered individually for each display line, and may have it's basic unit converted into an alternative unit as desired. This is useful for production line pass/failure testing of power supplies etc.

2.3.6 A "blank" line, containing two 'dashes' centered in the line.

2.3.7 The present time of day, in either 24 or 12 hour formats.

2.3.8 The present date, in dd/mm/yy, mm/dd/yy or yy/mm/dd formats.

2.3.9 Both the time of day and the date with the format selection described above.

2.3.10 The length of time over which any "accumulated" (e.g. WHr) data has been collected.

2.3.11

2.4. Deleting a Data Display Line

1:Using the arrow keys, make the line to be deleted visible in the display window.

2:Press the SELECT key for the line containing the data to be deleted from the list.

3:Press the SELECT 1 key until "Delete" is displayed in the uppermost display line.

4:Press the ENTER key.

The selected display data line is now deleted from the list.

2.5. Adding or Editing a Data Display Line

This can be initiated using any of the following methods :

1:Press the SELECT key for a completely blank display line. A 'new' display data item will be started in the selected line.

2:Press any parameter key in the "PARAMETER & EQUATION CONTROL" section of the front panel. A new display item will be started following the last defined display data line, using the selected parameter as its starting parameter.

3:Press the SELECT key for a presently used display line. The definition for that display line will be "opened" for editing.

The exact procedure for selecting the data to be displayed on the selected line is dependent on the various selections, the following notes will assist the user in making these selections -

Line 1 :

Select the desired display data type (by repeatedly pressing the SELECT 1 key) before making any other selections. For non-measured parameter types this is the only selection required.

Line 2 :

When selecting a measurement parameter, always start by selecting the leftmost item first, then work towards the right. A list of parameter "types" (always the leftmost data) and their available parameter "sources" is shown later in this document.

Many parameters have both a "input coupling" (DC, AC, and AC+DC) and a "harmonic range" (NN-NN) frequency range type. These may be "toggled" between by pressing the "Harmonic" key in the "General" section of the keyboard. When entering a harmonic range: setting the second harmonic number to the same as the first yields the result at that harmonic only; setting the second harmonic number to zero yields the result measured over the entire measured range of harmonics starting at the first harmonic number; setting the second harmonic number to any other value yields the result measured over the defined range of harmonics (inclusive). Entering a range extending beyond that defined as the maximum measured harmonic for the particular channel may not yield reliable results.

Certain other parameters (e.g. THD and Triplens) have a maximum harmonic frequency range type ( ). In this case the result is measured over the harmonic range from the lowest defined for that parameter (e.g. 2^{nd} for THD, 3^{rd} for triplens etc.) up to and including that defined by the user. Entering a range extending beyond that defined as the maximum measured harmonic for the particular channel may not yield reliable results.

"Spectrum" parameters have a single numeric spectrum point number, this type of data is only suitable in "advanced" applications, where the user has either defined a "spectrum" type measurement on the selected channel, or is aware of the user defined relationship between "spectrum point" and "harmonic number".

"Dual Input" parameters (e.g. Gain, Real, Imag and Phs) require a pair of inputs and harmonic numbers. The result is either the ratio between these two inputs/harmonics (Gain), or the first input/harmonic using the second input/harmonic as a phase reference. The user may specify the same input in both positions. The results other than "Gain" are only meaningful if both defined inputs are contained within the same channel or the same synchronous group of channels.

Line 3 (reference type) :

"Ref = " indicates that the following numeric quantity has been selected as the reference or nominal value for the parameter defined on line 2. The LEFT and RIGHT arrow keys "toggle" between the "Ref =" and numeric quantity selections. When the cursor is in the "Ref =" selection, the UP and DOWN arrow keys toggle between the various reference or nominal value selections.

"Updated Ref. Param." indicates that a continuously updated parameter value is to be used as the reference or nominal value.

"Fixed Ref. Param." indicates the a previously measured parameter value is being used as the reference or nominal value. This value may be viewed by toggling to the "Ref =" selection.

"Fix Ref. Param. Now" indicates that the value of the reference/nominal parameter will be measured and "fixed" when the ENTER key is pressed and this is being displayed. This selection is only available is a parameter has been previously defined for the reference or nominal value. If no parameter is presently defined then select the "Updated Ref. Param." selection, press the ENTER key, select the SELECT 4 key and edit the parameter to that desired as the reference, then press the SELECT 3 key to return to this line and make the desired selection.

Line 4 (reference parameter) :

This is available if the reference type selected in line 3 is either "Updated Ref. Param." or "Fixed Ref. Param.".

The selection method is the same as for line 2.

The selection may be identical to that in line 2 (yielding the deviation from a previously measured value).

"Display as" line :

The line number used by this selection is dependent on the data type and reference type selections.

The user should use the relevent SELECT key to select the desired display unit for the result. All necessary conversions are automatically performed during units conversion. The user should note that all reference and limits computations are performed prior to the requested units conversion.

Limit = Line :

This is only available for the "Limit Param" data type. The user may enter any numeric value, which will be used to define the high (nominal + limit) and low (nominal - limit) levels of the PASS region.

"Filter =" Line :

The user may enter any value between 0 (no filtering) up to 1000 seconds as the filter time constant. The filter is a single pole filter with an automatic filter bypass when the result changes by more than 10%. Even when not being displayed, this filter is active, maintaining the averaged result at all times. This is useful to display the "mean" line voltage or current when an unregulated power source is being used (a filter period of 2 seconds is recommended for this purpose).

2.6. Displayed Data Format

Data is displayed in four columns of information as follows (from left to right) -

1:A brief description of the method of measurement of the displayed data.

2:The measured/computed result. If data is not available (usually due to the lack of a measurable fundamental frequency) then "dash" characters replace the numbers.

3:The units of the displayed result. "Lead" or "Lag" is displayed for power factor information.

4:The primary input/channel/group/set of groups from which the displayed result was measured.

2.7. Available Displayed Parameter Types

The following "base" parameter types are available for display. All of these data are computed each measurement, irrespective of whether the data is actually displayed or not.

True RMS The measured true RMS voltage or current (use the "V" and "A" keys to select which), select either DC only, AC only, AC+DC or a range of harmonics for the bandwidth of the measurement. This data is available for any input of any channel.

Rectify The average rectified voltage or current (unscaled, use the "V" and "A" keys to select which). This data is always measured using AC+DC bandwidth and is available for any input of any channel.

FF Voltage or Current Form Factor (use the "V" and "A" keys to select which). This data is always measured using AC+DC bandwidth and is available for any input of any channel.

CF Voltage or Current Crest Factor (use the "V" and "A" keys to select which). This data may be measured using AC only or AC+DC bandwidth and is available for any input of any channel.

High Pk The highest instantaneous level of the selected input signal (use the "V" and "A" keys to select which input) during a single measurement period. This data is always measured using AC+DC bandwidth and is available for any input of any channel.

Low Pk The lowest instantaneous level of the selected input signal (use the "V" and "A" keys to select which input) during a single measurement period. This data is always measured using AC+DC bandwidth and is available for any input of any channel.

Peak The highest instantaneous excursion from zero of the selected input signal (use the "V" and "A" keys to select which input) during a single measurement period. This data is always measured using AC+DC bandwidth and is available for any input of any channel.

Pk-Pk The difference between "High Pk" and "Low Pk" for the selected input (use the "V" and "A" keys to select which input) during a single measurement period. This data is always measured using AC+DC bandwidth and is available for any input of any channel.

Inrush The highest "Peak" measurement recorded for the selected input (use the "V" and "A" keys to select which input) during any measurement period. This data is always measured using AC+DC bandwidth and is available for any input of any channel. This data may be cleared at any time by pressing the INRUSH key.

Acc. Max The highest "High Pk" measurement recorded for the selected input (use the "V" and "A" keys to select which input) during any measurement period while accumulating. This data is always measured using AC+DC bandwidth and is available for any input of any channel.

Acc. Min The lowest "Low Pk" measurement recorded for the selected input (use the "V" and "A" keys to select which input) during any measurement period while accumulating. This data is always measured using AC+DC bandwidth and is available for any input of any channel.

Acc. Pk. The highest "Peak" measurement recorded for the selected input (use the "V" and "A" keys to select which input) during any measurement period while accumulating. This data is always measured using AC+DC bandwidth and is available for any input of any channel.

RMS.Hr The summation of "True RMS" measurements recorded for the selected input (use the "V" and "A" keys to select which input) during any measurement period while accumulating. This data may be measured using DC only, AC only or AC+DC bandwidth and is available for any input of any channel.

$Charge The summation of DC coupled "True RMS" measurements recorded for the selected input (use the "V" and "A" keys to select which input) having a positive polarity during any measurement period while accumulating. This data is available for any input of any channel. This data is only available in software versions 2.00 and higher.

$Dchrge The summation of DC coupled "True RMS" measurements recorded for the selected input (use the "V" and "A" keys to select which input) having a negative polarity during any measurement period while accumulating. This data is

available for any input of any channel. This data is only available in software versions 2.00 and higher.

THD-Fund The Total Harmonic Distortion recorded for the selected input (use the "V" and "A" keys to select which input), measured up to and including the selected harmonic, expressed as a ratio to the signal content at the fundamental frequency.

THD-Harm The Total Harmonic Distortion recorded for the selected input (use the "V" and "A" keys to select which input), measured up to and including the selected harmonic, expressed as a ratio to the signal content at all harmonics from the fundamental up to and including the selected harmonic.

THD-Sig The Total Harmonic Distortion recorded for the selected input (use the "V" and "A" keys to select which input), measured up to and including the selected harmonic, expressed as a ratio to the AC+DC RMS measurement of the signal.

K-Factor The measured K-factor measured for the selected input (use the "V" and "A" keys to select which input), measured up to and including the selected harmonic.

Triplen The summation of all "third" order harmonics (i.e., 3^{rd}, 6^{th}, 9^{th} etc.) measured for the selected input (use the "V" and "A" keys to select which input), measured up to and including the selected harmonic.

Odd Trip The summation of all odd "third" order harmonics (i.e., 3^{rd}, 9^{th}, 15^{th} etc.) measured for the selected input (use the "V" and "A" keys to select which input), measured up to and including the selected harmonic.

Evn Trip The summation of all even "third" order harmonics (i.e., 6^{th}, 12^{th}, 18^{th} etc.) measured for the selected input (use the "V" and "A" keys to select which input), measured up to and including the selected harmonic.

Wye-V The computed phase-to-neutral voltage for a 3-phase 3-wire "delta" connected group of channels.

Delta-V The computed phase-to-phase voltage for a 3-phase 4-wire "wye" connected group of channels.

Frequncy The measured frequency (input specified), or harmonic frequency (channel specified).

Watts The measured true real power for the selected channel, group of channels, total of all input groups or total of all output groups. A bandwidth of DC only (this a actually VA), AC only, AC+DC or measurement over a range of harmonics may be specified.

VAR The measured true reactive power for the selected channel, group of channels, total of all input groups or total of all output groups. A bandwidth of AC only, AC+DC or measurement over a range of harmonics may be specified.

VA The measured apparent power for the selected channel, group of channels, total of all input groups or total of all output groups. A bandwidth of DC only, AC only, AC+DC or measurement over a range of harmonics may be specified.

PF The measured true power factor for the selected channel, group of channels, total of all input groups or total of all output groups. A bandwidth of AC only, AC+DC or measurement over a range of harmonics may be specified.

DPF The measured dissipation power factor for the selected channel, group of channels, total of all input groups or total of all output groups. This is the same as specifying a measurement of PF for the fundamental only.

Eff.Phs. The inverse cosine of the measured true power factor for the selected channel, group of channels, total of all input groups or total of all output groups. A bandwidth of AC only, AC+DC or measurement over a range of harmonics may be specified.

Pk VA The highest instantaneous excursion from zero of multiplication of the selected channels' voltage and current waveforms during a single measurement period. This data is always measured using AC+DC bandwidth and is available for any channel.

W.Hr The summation of "Watts" measurements recorded for the selected channel/group/group of groups during any measurement period while accumulating. This data may be measured using DC only, AC only or AC+DC bandwidth.

VAR.Hr The summation of "VAR" measurements recorded for the selected channel/group/group of groups during any measurement period while accumulating. This data may be measured using DC only, AC only or AC+DC bandwidth.

VA.Hr The summation of "VA" measurements recorded for the selected channel/group/group of groups during any measurement period while accumulating. This data may be measured using DC only, AC only or AC+DC bandwidth.

Load Z The effective impedance load (expressed in either resistance or conductance units) for the selected channel. The user may specifiy bandwidths of DC only, AC only, AC+DC, or a range of harmonics for the measurement.

Load R The effective "real" resistive load (expressed in either resistance or conductance units) for the selected channel. The user may specifiy bandwidths of DC only, AC only, AC+DC, or a range of harmonics for the measurement. The result

assumes a load containing the series combination of a real and imaginary component.

Load X The effective "imaginary" reactive load (expressed in either resistance or conductance units) for the selected channel. The user may specifiy bandwidths of AC only, AC+DC, or a range of harmonics for the measurement. The result assumes a load containing the series combination of a real and imaginary component.

Pwr Loss The difference between the total AC+DC input "Watts" and the total AC+DC output "Watts".

Efficiency The ratio of the total AC+DC output "Watts" and the total AC+DC input "Watts".

Spectrum The detected signal RMS amplitude at the frequency of the defined spectrum "bin".

Spect Hz The frequency corresponding to the selected spectrum "bin".

Gain The ratio of the RMS signal of the first selected input/harmonic to the RMS signal of the second input/harmonic.

Gre The "real" part of the ratio of the RMS signal of the first selected input/harmonic to the RMS signal of the second input/harmonic.

Gim The "imaginary" part of the ratio of the RMS signal of the first selected input/harmonic to the RMS signal of the second input/harmonic.

Real The "real" part of the RMS signal of the first selected input/harmonic using the second input/harmonic as its' phase reference.

Imag The "imaginary" part of the RMS signal of the first selected input/harmonic using the second input/harmonic as its' phase reference.

Phs The phase difference between the first selected input/harmonic and the second input/harmonic.

2.8. Detailed Configuration

Under most circumstances the configuration automatically provided by the "quick start" options will immediately yield accurate measurement results. In abnormal applications, or where more detailed control is required the user may provide more detailed configurations. This is achieved by pressing either the SYSTEM or CHANNEL key and selecting the "Channel Grouping" line.

The first displayed menu shows all three groups of channels and their basic configuration data arranged in tabular format.

2.8.1 *CHNL*

This column shows the channel groupings. All "grouped" channels are measured synchronously, thus inter-channel phase measurements are possible. This also enables the instrument to measure the inter-phase voltage in "wye" connected 3-phase systems and the phase-neutral voltage in 3-phase "delta" systems. If these types of results are not required, there is no advantage to synchronizing channels, and the user is recommended to leave them asynchronous (i.e. in separate groups) for full flexibility in configuration.

Channels may be "moved" between groups by "picking" the desired channel using the LEFT and RIGHT arrow keys and then "moving" it into the desired group using the UP and DOWN arrow keys.

2.8.2 *TYPE*

"off" - the channels are maintained in a safe state and no measurements are available.

"norm" - the channels are measured synchronously, but no further assumptions are made regarding their relative phase rotation etc.. This would be used where channels are to measure synchronously, but they are not connected in a 3-phase "delta" or "wye" configuration, this is also used for a group containing only one channel (see also below). The "total" power (or VA or VAR etc.) of this type of group is merely the vector summation of the individual channel measurements.

"3,4w" - the channels are connected to measure a 3-phase 4-wire ("wye") system. Generally the group should contain all three channels, however the necessary conversions and phasing detection will be performed if only one or two channels are in the group. It should be noted that it is assumed to be a balanced load if only one or two channels are in the group. Phase-to-Phase voltage is available for display from any channel contained in this group, an error being displayed if the relative phase rotation between the channels cannot be determined (i.e. the nominal phase is not approximately 120$).

"3,3w" - the channels are connected to measure a 3-phase 3-wire ("delta") system. Generally the group should contain either all three channels or any two channels, the necessary conversions and phasing detection will be performed if two or three channels are in the group. It should be noted that it is assumed to be a balanced load if only one channel is in the group. Phase-to-Neutral voltage

is available for display from any channel contained in this group, an error being displayed if the relative phase rotation between the channels cannot be determined.

2.8.3 *I/O*

"in" - the channels' power measurements are included in the "input" total for the instruments' power loss and efficiency calculations.

"out" - the channels' power measurements are included in the "output" total for the instruments' power loss and efficiency calculations.

"aux" - the channels' power measurements are not included in either the "input" or "output" totals.

2.8.4 More

Moving the cursor into this field opens the detailed group configuration menu for this group of channels.

2.9. Detailed Group Configuration Menu

This menu has three variants dependent on the type of configuration desired by the user.

2.9.1 Standard Setup

This variant will provide the desired configuration in most circumstances, with the "fine" details regarding the measurements being set to default values dependent on the "simple" details encountered in this menu.

Fundamental Frequency Range

This is the allowable range of measured fundamental frequencies. Normally this should be left at the maximum possible range (usually a 100:1 range), however it may be desirable to eliminate any mismeasurement caused by a highly significant harmonic signal content (in which case the range should be narrowed to exclude the frequency of that harmonic).

Selecting an unnecessarily low minimum fundamental frequency will yield significantly slower autoranging and settling times upon signal application.

Selecting a erroneously high minimum fundamental frequency will allow the instrument to autorange within a single period of the applied waveform.

A range of 40Hz to 1KHz is recommended for all line power frequencies. A range of 10KHz to 500KHz is recommended for all high frequency measurements. Selections below 1Hz are only recommended when the user is sure this is required (selecting a 0.0001Hz minimum in this mode will yield a measurement which could take almost 1 day to complete!).

(Software versions prior to 2.00 only). An input filter of approximately 1000 times the minimum fundamental frequency is automatically provided in this Setup method. Harmonic measurements of up to the 49^{th} harmonic are provided by this setup, using a harmonic bandwidth of 25% of the fundamental frequency, and using a "windowed" Fast Fourier Transform technique.

Synchronization Source

The user may select any combination of the channels contained within the group, or any single channel not contained within the group as its' source of the measurement of fundamental frequency. For the channel(s) selected, the user may select automatic selection of either the Voltage or Current input, only the Voltage input, or only the Current input as the source of this data. When using a channel which is a member of another group, it should be noted that the parameters concerning the measurement of the fundamental frequency for this group have no affect on that channels' capability of measuring the fundamental for its' own group (e.g. a single channel can measure three different frequency components from a single input and separately user these for synchronizing all three channels!).

Minimum Measurement Period

This is the minimum amplitude measurement period for all channels within the group and for the measurement of fundamental frequency by whichever channel is performing that function. With this setup method the actual measurement period is typically within 10% + 10ms of the entered period.

Input Filter Corner Frequency (software versions 2.00 and later only)

The user can specify the 1dB corner frequency of an 8-pole elliptic filter applied to the input waveforms within the group.

Harmonic Analysis (software versions 2.00 and later only)

The user can select whether harmonic analysis is to be performed. If enabled, then IEC555.2 compliant analysis is always selected using the Standard Setup method.

2.9.2 Spectrum Setup

This allows the user to perform a spectrum analysis of the input waveforms, using a user defined frequency step and maximum frequency for the "sweep". Normal measurement results are still available during measurements defined by this setup mode, but no synchronization to a measured fundamental frequency is performed, and the amplitude measurement period is simply one period of the step frequency.

This setup technique would normally be used under interface control to display spectral content in a visual manner.

2.9.3 Advanced Setup

This allows the user to fully control all aspects of amplitude, frequency and harmonic signal measurements and analysis. If it is necessary for the user to use this setup technique, it is highly recommended that a "standard setup" be performed for this group first, and then an "advanced setup" started. This will set all parameters to the factory default values before being edited by the user.

Fundamental Frequency

The user may select for either the measured sync. frequency (default), the measured sync. frequency times a scale factor (for phase locked loops), or a fixed frequency (for the most severe noise situations), to be used as the groups' fundamental frequency.

Sync. Frequency Range

The user should enter the allowable measured sync. frequency range (up to a maximum of 100:1). This only affects the measurement of the sync. frequency, and is only available if a fixed fundamental frequency was not selected.

Sync. Source

The user may select any combination of the channels contained within the group, or any single channel not contained within the group as its' source of the measurement of fundamental frequency. For the channel(s) selected, the user may select automatic selection of either the Voltage or Current input, only the Voltage input, or only the Current input as the source of this data. When using a channel which is a member of another group, it should be noted that the parameters concerning the measurement of the fundamental frequency for this group have no affect on that channels' capability of measuring the fundamental for its' own group (e.g. a single channel can measure three different frequency components from a single input and separately user these for synchronizing all three channels!).

Minimum Amplitude Measurement Period

This is the minimum amplitude measurement period for all channels within the group. With this setup method it is possible that much longer measurement periods will be needed, particularly if the fundamental:bandwidth ratio is large.

Input Filter Corner Frequency

The user can specify the 1dB corner frequency of an 8-pole elliptic filter applied to the input waveforms within the group.

Harmonic Analysis Configuration (software versions 2.00 and later only)

The user can select whether harmonic analysis is to be performed, and the configuration of this analysis. This is acheived by the user selecting from several choices.

The "None" choice disables all harmonic analysis within the selected group of channels.

The "Simple" choice enables harmonic analysis within the selected group of channels. A single analysis is performed each measurement period with the bandwidth, maximum number of harmonics, and FFT window type defined by the user.

The "Averaged" choice enables harmonic analysis within the selected group of channels. Multiple analyses are performed each measurement period with the bandwidth, maximum number of harmonics, and FFT window type defined by the user, with the results being averaged over the entire measurement period.

The "IEC555.2" choice enables harmonic analysis within the selected group of channels. The analysis performed is compliant with the IEC555.2 standard, no other definition of analysis parameters are required.

Maximum Harmonic

This is only available if the Harmonic Analysis Configuration has been set to "Single" or "Averaged".

The user can set the maximum range for harmonic measurements. Typically the default value of 49 is recommended, however values down to 2 and up to 2048 are allowed. When large values are set, they may be overridden by the selection of the input filter corner frequency.

Fundamental / Bandwidth

This is only available if the Harmonic Analysis Configuration has been set to "Single" or "Averaged".

This integer value sets the bandwidth for the measurement of each individual harmonic. Changing this value from the default of 4 may either improve or severely worsen the accuracy and stability of harmonic measurements. Generally, the user should only set large figures when it is known that the signal has little frequency modulation, it is desired to eliminate a high general noise content, and the fundamental frequency is below 10KHz. Lower figures than the default should only be used when necessary due to significant frequency modulation.

It is difficult to generalize the best selection for this parameter, the default setting of 4 has been derived as a best "general" value following several years of testing in earlier Xitron Technologies products. The user may wish to test values other than this, particularly high frequency, high FM applications.

This setting also has the affect of limiting the minimum amplitude measurement period to this number of input cycle periods, setting a very large number for this ratio will yield very long measurements (e.g. setting this to 1000:1 with a 0.0001Hz fundamental frequency yields a measurement period of more than 100 days!).

FFT Type

This is only available if the Harmonic Analysis Configuration has been set to "Single" or "Averaged".

By default, the 2503AH uses a modified Blackman-Harris type windowing technique to provide stable harmonic measurements throughout the frequency range and in most applications. In certain applications, and where extremely accurate inter-harmonic phase measurements are required, it may be desirable to select the "normal" (or square window) FFT. If excessive instability is found in harmonic measurements then the user may test both methods to determine which is best. In most cases the affects of the Fundamental/Bandwidth ratio and FFT type selections are interactive, and the user is strongly recommended to not adjust these unless absolutely necessary, or requested to do so by Xitron Technologies customer support staff.

Sync. Result Averaging

Normally the fundamental frequency is measured over the defined measurement period (see below) with no result averaging. This selection allows the user to impose result averaging on the measured sync. frequency. This is useful in situations where the sync. frequency has poor stability.

Sync. Measurement Period

This sets the measurement period of the sync. signal independently of the measurement period for amplitude.

Inter-Channel Phasing

When a group of channels have been configured as measuring a 3-phase 3-wire (or Delta) system, then the instrument needs to known the relative phasing of each channel in order that the channels can be correctly combined to produce total power etc.. This menu item allows the user to specifiy which channel(s) are "in rotation". The user should set this line to include all channels within the group which have their voltage terminals connected such that the phase connected to the LO terminal is ahead of the phase connected to the HI terminal.

If the user is unsure as to the correct settings, try the following -

For a two channel measurement of a delta configuration, set only one channel as being in-phase. For a three channel measurement set all channels as being in-phase.

If the total power is correctly computed by the instrument, but the total power factor has the reverse lead/lag indication to that expected, then reverse all channels in this menu setting.

If the total power is not correctly computed by the instrument, or "INVALID PHASE" is displayed, then one or more (but not all) settings in this menu setting are not correct.

2.10. Setting Ranges, Selecting Current Inputs, Setting PTs and CTs

These are all performed with menus selected by the user pressing the RANGE key.

The 2503AH family has three choices for current input terminals: internal current shunt (0.05A to 20Arms ranges); internal hall effect transducer (5A to 40Arms ranges); and external shunt/CT voltage input (0.01V to 5Vrms ranges). The initial menu after pressing the RANGE key allows the user to select the voltage input range, and the current input terminals and range.

In this menu the user may select the desired channel by using the respective SELECT key, select the desired action (voltage range, current range or current input) using the LEFT and RIGHT arrow keys, and then select the desired range (or autorange) or the desired input terminals by using the UP and DOWN arrow keys.

Additionally the user may select any of the following actions by scrolling the menu (using the DOWN key with no cursor displayed) and selecting the respective display lines' SELECT key -

Display the present ranges actually being used.

This selection initiates a "read only" menu showing the ranges and input terminals actually in use at that moment, this display is continuously updated.

Setup CT and/or PT ratios (i.e. input scaling)

This selection allows the user to set a PT scaling ratio (applied to the voltage input) or CT scaling ratio (applied to any current input) for any channel. The channel is selected by pressing the SELECT 1 key, changing the displayed affected channel in the uppermost display line. A PT ratio may be selected by pressing the SELECT 2 key, then the UP arrow key to select an active PT ratio, then the RIGHT arrow key to select the ratio, then entering the required ratio. The user should note that the ratio is maintained when not in use, and that the measured voltage at the terminals of the instrument is multiplied by the entered scale factor.

The CT ratio is set similarly to the PT ratio, but is on display line 3. It should further be noted that the selected CT ratio scale factor (if any) is applied to any current input, allowing for current output CT's (using the internal shunt input terminals), multiple passes through the internal hall effect transducer, or an external shunt or voltage output CT (using the external shunt/CT voltage input).

Select the ranging technique.

Under "normal" circumstances the instrument will attempt to autorange to provide enhanced input protection at all times (even when a fixed range is selected). In the rare circumstance that this is not the desired action, the user may select for the "Strict" ranging mode, where the instrument will "hold" a selected "fixed" range under all circumstances.

The state of this flag is always volatile and will default back to "normal" ranging following reset.

The "Input Scaling" Menu is also available by selection under the menu initiated by pressing the CHANNEL key.

2.11. Configuring Frequency Measurements

Inputs which are used as sync. sources for one or more channel(s) are configured according to the fundamental frequency requirements of the group using that input as its' sync. source. These inputs may not otherwise be configured for independent frequency measurement.

Inputs which are not configured as potential sources of a fundamental frequency may be configured for independent frequency measurement. This may be achieved by pressing the CHANNEL key followed by the SELECT 3 key. The user may then configure any inputs available for such measurements.

2.12. Controlling Inrush Parameters

"Inrush" voltage and current are continuously updated with the highest peak excursion from zero found. These parameters may be "cleared" by pressing the INRUSH key when no menu is being displayed.

2.13. Controlling Accumulated Parameters

"Accumulated" parameters (e.g. WHr etc.) may be "started", "paused", and "cleared" by a menu initiated by pressing the ACCUMULATE or ACCUM keys.

These parameters are being updated when the ACCUMULATE LED annunciator is illuminated, this action is initiated by selecting to "start" an accumulation.

An "accumulation" may be "paused" (i.e. the accumulated parameters are held at their present values) by selecting the "pause" option. This causes the ACCUMULATE LED to extinguish. Subsequently selecting the "start" option, without "clearing" the results, will restart the accumulation from the results at which it was "paused".

"Accumulation" results may be "cleared" by selecting this option. This resets all accumulated parameters to their initial states. This may be performed at any time, including when an "accumulation" is in progress. This is the only available selection when the "accumulation" is configured as being controlled by the rear panel control input.

2.14. Holding Measurements

When input signals are only present for a limited period of time it is often desirable to "hold" the measured results and then display the measured results at "leisure" after the input has become inactive. This can easily be achieved by pressing the RUN/HOLD key. This key "toggles" between the RUN (i.e. normal operation, LED extinguished) and the HOLD states (i.e. held measurements, LED illuminated). When the rear panel control input is configured as controlling this state the HOLD key accesses the Rear Panel Control Input Configuration Menu.

2.15. Configuring the Rear Panel Control Input

The rear panel control contact closure/TTL input may be configured as controlling nothing (i.e. inactive), controlling "accumulation", or controlling run/hold. This is achieved by pressing the SYSTEM key and selecting the Rear Control display menu line, and making the respective selections. As a check feature, the menu displays the current state of this input in the lowest display line of this menu.

2.16. Setting the Time and Date Data and Format

This is achieved by pressing the SYSTEM key and then selecting the "Set Time and Date" selection of that menu.

The user may "toggle" the 12/24 hour time format selection by pressing the SELECT 1 key.

The user may "toggle" the date format selection by pressing the SELECT 2 key.

The user may set the correct time by pressing the SELECT 3 key, and then entering the correct time (in 24 hour format only) using the number keys. The ENTER key should be pressed when the correct time has been entered (the clock is set to the entered time at the moment that the ENTER key is pressed).

The user may set the correct date by pressing the SELECT 4 key, and then entering the correct date (in the selected format) using the number keys. The ENTER key should be pressed when the correct date has been entered (the clock is set to the entered date at the moment that the ENTER key is pressed).

2.17. Saving an Instrument Configuration

Up to 65536 different configurations of channel groupings, group configurations, frequency measurement configuration, input range/terminal selections, CT and PT selections, and rear panel control selections may be stored in a non-volatile manner.

The instrument will always restore the last recalled store when recovering from power application.

Instrument Configuration may be stored by -

1.Press the STORE key.

Either -

2.Display and select the desired store number using the UP and DOWN arrow keys and the respective SELECT key.

Or -

3.Enter the desired number directly using the number keys and then pressing the ENTER key. New stores may be created by using this technique.

A presently valid store number may have a character string "attached" as its' name by following the procedure below -

1.Press either the STORE or RECALL key.

2.Press the EDIT_DIRECTORY selection. (SELECT 2 key).

3.Select the required store number by using the UP and DOWN arrow keys and the corresponding SELECT key, or by entering the store number using the number keys.

4.Press the SELECT 2 key.

5.A "name" may then be entered using the UP and DOWN arrow keys to change the character at the cursor position, and the LEFT and RIGHT arrow keys to move the cursor position.

2.18. Recalling a Previously Stored Instrument Configuration

Instrument Configuration may be recalled from non-volatile memory by -

1.Press the RECALL key.

Either -

2.Display and select the desired store number using the UP and DOWN arrow keys and the respective SELECT key.

Or -

3.Enter the desired number directly using the number keys and then pressing the ENTER key.

A presently valid store number may have a character string "attached" as its' name by following the procedure below -

1.Press either the STORE or RECALL key.

2.Press the EDIT_DIRECTORY selection. (SELECT 2 key).

3.Select the required store number by using the UP and DOWN arrow keys and the corresponding SELECT key, or by entering the store number using the number keys.

4.Press the SELECT 2 key.

5.A "name" may then be entered using the UP and DOWN arrow keys to change the character at the cursor position, and the LEFT and RIGHT arrow keys to move the cursor position.

2.19. Removing a Previously Stored Instrument Configuration

A previous stored instrument configuration may be removed from the non-volatile memory by -

1.Press either the STORE or RECALL key.

2.Press the EDIT_DIRECTORY selection. (SELECT 2 key).

3.Select the required store number by using the UP and DOWN arrow keys and the corresponding SELECT key, or by entering the store number using the number keys.

4.Press the SELECT 3 key.

Although many sets of configurations may be stored in the non-volatile memory, "unused" sets should always be deleted or reused to conserve memory.

2.20. Checking the Status of the Instrument

The instrument performs many self-test procedures during recovery from power application. Any faults found during this testing are displayed at that time. Many of these faults are not "fatal", and the instrument may still be used. The status of the instrument with respect to power application fault detection, non-volatile and volatile memory usage, inter-processor communication noise and calibration data status may be viewed by the following procedure -

Press the CALIBRATE/TEST key.

Press the SELECT 1 key (next to "System Status").

The instrument will then sequentially display the following information -

The versions of each processors' software

The "retry" rate of communications with each DSP (useful for finding "marginal" faults in digital circuitry).

The type and percentage used of the internal non-volatile "flash" memory. If more than 75% of this memory is in use, then the instrument automatically attempts to "reorganize" its' contents to recover any unused memory (this is rather similar to defragmenting a hard disk on your computer - but much faster!). If the instrument does not recognize the device type (i.e. displays "unknown device") this indicates a marginal device and corrective action should be taken.

The amount and highest percentage used of the internal central processor volatile memory (RAM). This should normally display 128Kb fitted. If very high (greater than 80%) percentage usage figures are displayed then this indicates that a large portion of the instruments' processing capabilities have been used since the instrument was last powered up.

The number of days since the last internal / input / external calibration was performed successfully on each channel. If data has been "lost" (become corrupted) then "req" is displayed instead of the days since last calibrated. NOTE - main software versions prior to 1.4 do not have this facility, if the previous calibration was performed using a version prior to this, but the instrument now has software at (or later than) this version, then a "?" is displayed as the days since last calibrated. Internal Calibration is recommended at 10 day intervals (or a 5$ change in ambient temperature). Input Calibration is recommended at 30 day intervals (or a 5$ change in ambient temperature). External Calibration is recommended annually.

The final message indicates that an Input Calibration is recommended if the user wishes to test the analog circuitry of the instrument.

2.21. Performing an Internal or Input Calibration on the Instrument

An "Internal" calibration of the instrument may be performed at any time, even with signals applied to the instrument terminals. This fully automatic procedure calibrates and tests the Analog-to-Digital Converters, input filters and references on each channel. Internal Calibration is recommended at 10 day intervals (or a 5$ change in ambient temperature).

1.Press the CALIBRATE/TEST key

2.Press the SELECT 2 key

3.The instrument will perform the tests on each channel independently, during the same period of time (gambling on which channel will finish first is not recommended!).

4.When all tests have been completed the display will show the status of each channel and the instrument waits for the user to press any SELECT key to return to normal operation.

An "Input Calibration" performs DC offset adjustments on each input, each mode, and each range. This procedure requires that the user remove all signals from the input terminals to the instrument. If an external current shunt or CT is connected to a "bypass" current input, then this should remain connected such that its' DC offset may be automatically corrected also (if this is performed then the "Input Calibration" will have to be repeated if those terminals are used with a different CT or shunt).

An "Internal Calibration" is automatically performed prior to testing the inputs on each channel.

1.Press the CALIBRATE/TEST key

2.Press the SELECT 3 key

3.The instrument will perform the tests on each channel independently, during the same period of time (gambling on which channel will finish first is not recommended!).

4.When all tests have been completed the display will show the status of each channel and the instrument waits for the user to press any SELECT key to return to normal operation.

2.22. "Locking" the Instruments' Configuration

A slide operated switch is located on the rear panel, just above the power receptacle. This switch may be used to disable any reconfiguration of the instrument by any front panel means other than recalling previously stored configurations.

This switch is recessed into the rear panel, allowing the user to place a "paper seal" over the seal to prevent unauthorized reconfiguration.

The following actions are not permitted while this switch is in the "disabled" position -

Changing any display line parameters or types.

Storing Instrument Configurations.

Changing channel groupings or group configurations.

Changing range and terminal selections for any channel.

Changing Input Frequency Measurement Configurations.

Performing "Input" or "External" Calibrations.

3. DIGITAL CONTROL INTERFACING

The **2501/2/3AH** family has optional IEEE488 and RS232 interfaces, which may be configured to allow the instrument to be both controlled and interrogated by a computer.

Both interfaces operate in similar manners, using the same command set. The major difference between the operation of these interfaces is in the ability of the IEEE488 interface to switch between remote and local command states (which the RS232 interface does not offer), and the ability of the controller to continuously read the same data from the IEEE488 interface (the controller must always prompt the instrument to transmit the desired data from the RS232 interface).

Throughout this section it is assumed that the user is conversant with manual operation of the instrument, and with the methods of operating the controller for the particular interface being used.

3.1. RS232 Data Format Selection

The user should ensure that the computer connected to the RS232 port is set to the same baud rate as the instruments' serial port, 8 bit data with no parity, 1 stop bit and 1 start bit. In normal operation the user should select the highest baud rate (38400 baud), however it should be noted that some IBM PC compatible computers do not operate correctly at this speed, particularly when operating in a multi-tasking environment (such as *Microsoft Windows*®). When operating in environments having severe interference, when using very long cable lengths, or when the user is unsure whether the computer is capable of the highest baud rate, the user may wish to decrease the selected baud rate to reduce data transfer error rates.

3.2. Remote/Local Operation

In the RS232 interface there are no defined REMOTE or LOCAL states, thus the instrument will respond to commands from either the front panel or the interface as applicable. The IEEE488 interface defines separate REMOTE and LOCAL states for the instrument thus this paragraph is only applicable to this interface.

While in the LOCAL state (e.g., following the initial application of power) the instrument will only respond to commands from the front panel of the instrument. After placing the instrument in the REMOTE state (via the defined interface command) the instrument will only respond to commands received via the interface (until released into the LOCAL state by the defined interface command, or by the user pressing the ***LOCAL*** key on the front panel). In either state, the instrument may have its present status read by the interface.

The REMOTE state is entered in the manner defined by the IEEE488 interface bus, normally this is achieved automatically when the instrument is correctly addressed to "listen" to a command string.

3.3. Configuring the Instrument and Controller (IEEE488)

Throughout this section of the manual, the use of a National Instruments AT-GPIB® IEEE488 controller board in an IBM AT (or compatible) is assumed. If the user is using a different controller or a controller card from another vendor, then the exact methods used will differ from those shown. If the user is using a computer with a built-in interface (such as the Hewlett-Packard series 300 and similar computers) then no configuration is usually required.

3.3.1 Configuring the Instrument

Other than enabling the interface to act as a control interface, setting the desired address and connecting the IEEE488 cable, the user need not perform any specific configurations on the instrument. As with all IEEE488 instruments and devices, the user must ensure that the selected address does not conflict with any other devices in the system. When using the instrument with the National Instruments controller card (and with many other cards for the IBM AT) the user should not select an instrument address of 0, as this will conflict with the address of the card.

3.3.2 Configuring the Controller Card

The user should follow the manufacturers recommended installation procedure when installing the card in the computer. Where an IBM PC (i.e., 8-bit) card is to be installed into an IBM AT type machine (i.e. 16-bit or higher), the user should take particular note of the hardware interrupt and DMA channel selected for the card.

Most manufacturers of these cards set these parameters to those compatible with the IBM PC, unfortunately these usually conflict with other cards normally found in the IBM AT class computers. In particular the user should beware that the first parallel port in an IBM AT class computer uses interrupt IRQ7.

When a conflict occurs between interrupts and DMA channels, the problems may not appear for some time, or may only cause intermittent operation. When any doubt occurs the user is recommended to first deselect the DMA channel, and then (if the problem persists) deselect the IRQ. Although this will perform slightly slower than the published specifications for the card, this will ensure that no conflicts occur.

The user also should note that some 8-bit cards will not reliably operate in high speed computers (such as 80386 based machines), the user should consult the manufacturer of the card regarding this issue.

When operating using hardware interrupts and DMA channels, and the computer is operating under the control of multi-tasking software (such as *Microsoft Windows*), then there are many other issues that require attention. In these circumstances the user should consult with the vendor of the controller card for specific configuration details.

3.3.3 Configuring the Controller Software

With the National Instruments AT-GPIB controller card, and with many other cards, there is a configured *device driver* installed in the computer. This driver must be correctly configured to ensure reliable operation with the **2501/2/3AH**. This section describes the settings that have been tested with the National Instrument AT-GPIB driver revision 1.5 accessed with the *ibconf* program supplied with the controller card, other drivers and revisions may be similar to those shown below :

Controller Card Configuration (***GPIB0***) : Note that these settings may be varied dependent on other instrumentation using the IEEE488 bus.

Primary Address	*0.*[1]
Secondary Address	NONE.[1]
Timeout Setting	T10s.[1]
EOS	00H.[1]
Terminate on EOS	no.[1]
Set EOI with EOS on Write	no.[1]
Type of Compare on EOS	7-bit.[1]
Set EOI w/last byte of Write	yes.
System Controller	yes.[2]
Assert REN when SC	no.[1,2]
Enable Auto Serial Polling	yes.[3]
Timing	500ns.[4]
Enable 488.2 Protocols	yes.[5]
CIC protocol	no.[2]
Interrupt Setting	11.[6]
Base I/O Address	02C0H.[6]
DMA Channel	5.[6]

NOTES :

1:These selections are only for data transfers regarding the controller card itself. Thus other settings may be used, but have not been fully tested by Xitron Technologies Inc..

2:These selections assume the use of a single controller. In configurations where a second controller exists these may be altered, other settings have not been fully tested by Xitron Technologies Inc..

3:The Xitron Technologies **2501/2/3AH** family does not currently use the SRQ and Serial Poll capabilities of the IEEE488 bus. This setting will be dependent on other instruments, thus does not affect the **2501/2/3AH** instruments.

4:Timings of longer than this are also valid. The 350ns selection has been tested on shorter cable lengths by Xitron Technologies Inc. and may be used, however in normal operation there is little overall performance gain by using it with the **2501/2/3AH** instruments. If other, very high speed, devices exist in the system then this shorter time may be selected.

5:The **2501/2/3AH** do not use the IEEE488.2 specifications, thus this setting has no affect on these instruments if the user has otherwise ensured that no IEEE488.2 type transfers take place with the **2501/2/3AH**. If all other devices also do not use the IEEE488.2 type transfers, then this setting should be set to *no* to ensure compatibility.

6:Although these settings have no affect on the **2501/2/3AH** instruments, the user should ensure that no hardware conflicts exist with other installed devices in the computer. The settings shown above are highly recommended, as the probability of conflict is lowest with these settings.

Settings for the **2501/2/3AH**. The user should note that, as documented in the National Instruments manual, the name given for the device should not exist as a file, directory, or sub directory within the computer system. If this occurs then unreliable operation of both the bus and the computer may result. Especially when operating in a network environment, it is recommended that the name given is cryptic to reduce the probability of this occurring.

Primary Address	*2.*[1]
Secondary Address	NONE.[1]
Timeout Setting	T1s.[2]
EOS Byte	0AH.[3]
Terminate read on EOS	yes.[4]
Set EOI with EOS on Write	no.[5]
Type of Compare on EOS	7-bit.[4]
Set EOI w/last byte of Write	yes.[5]
Repeat Addressing	no.[6]

NOTES :

1:The address should be that configured in the instrument. The **2501/2/3AH** does not use secondary addressing.

2:The only command that may hold the bus handshake for longer than 20ms. is the device clear command. If this command is not used then even shorter timeout periods can be used to detect a failure. The device clear command may hold the bus handshake for up to one second. When using the command pass-through feature of the MIB (i.e. controlling another instrument via the MIB) then longer timeout periods may be required.

3:The **2501/2/3AH** always sends a carriage return (0DH) and a line feed (0AH) with EOI asserted at the end of each data transfer from the **2501/2/3AH**.

4:Terminating a data read with the defined EOS byte ensures that data transfers are correctly terminated. This ensures that the user does not have to specify the exact number of characters for each transfer. Data transfers from the **2501/2/3AH** are all 7-bit ASCII data with no parity.

5:The **2501/2/3AH** will terminate a data receive operation with either a line feed character (0AH), or any character with EOI asserted, or with a device trigger. Selecting the EOI w/last byte of Write option ensures the shortest possible data transfer.

6:The **2501/2/3AH** does not "unaddress" at the completion of a transfer. Thus, assuming no other device has been subsequently addressed, there is generally no requirement to re-address the instrument. However, if the instrument is locally reset to the LOCAL state then it must be re-addressed to reenter the REMOTE state.

3.4. Reading Data From the 2501/2/3AH

With either interface the user may interrogate the various data held by the instrument. This is achieved by sending a "data read" command string (see the next section), which defines which data is to be interrogated, and then reading the data from the instrument. Up to 1000 characters may be read from the instrument as a result of sending a "data read" command.

In the **RS232** interface, this data is automatically transmitted from the instrument to the controller, the instrument will then wait for a further "data read" command before sending further data.

In the **IEEE488** interface, the controller may immediately attempt to read the requested data, the controller will then be held for a short delay (typically less than 1ms) until the requested data is available, then the requested data will be read by the controller. This data may be read by the interface any number of times, the data transmitted will always be the latest available data (unless the instrument is in the HOLD state).

In either interface, the instrument typically responds by sending a single "space" character, followed by a numeric string (with a preceding polarity symbol), followed by the respective "engineering format" exponent data in the form "*e+3*", and terminated by the "carriage return" and "line feed" characters (with the **IEEE488** interface this last character is sent with the EOI line asserted). Certain data do not follow this format, these are described in the following paragraphs (see the ***READ=*** command description). The user also may request more than one item of data is transmitted, here the individual items sent from the instrument are separated by means of the comma (,) character.

3.5. Sending Data to the 2501/2/3AH

Both the **RS232** and **IEEE488** interfaces operate similarly with regards to sending data to the instrument. The only difference being the previously mentioned requirement to place the instrument in the REMOTE state with the **IEEE488** interface. ASCII characters transmitted to the interface are stored in a "buffer" until either a "line feed" character is received, or a character with the EOI line asserted, or a "Group Execute Trigger" command is received. The received characters then are decoded and actioned.

Up to 1000 characters may be stored in the "receive buffer," which may contain more than one complete command string type if desired. If the user sends conflicting commands within the same command string, then the last effective command will be used.

Individual commands within the same strings should be seperated by the , (comma) or ; (semi-colon) characters. For commands which require several items of data, these data should be seperated by the / or : (colon) character (note that only the colon character may be used for the READ= command).

It should be noted that the **2501/2/3AH** operates with the received ASCII characters, the command used to send these characters via the designated interface is dependent on the computer system and peripheral used.

3.6. Special Considerations When Using RS232 Interfacing

The **RS232** interface is configured to use the RS232 hardware "handshake" lines RTS and CTS to handshake data. The usage of these hardware "handshake" lines ensures that data will not be lost due to different speeds in the **2501/2/3AH** and the computer. Sometimes the particular computer used is not able to use these handshake lines properly (e.g., some computer systems continue to transmit a few characters after being "held off" from transmitting). The user should place delays between sending individual command strings in these cases to prevent "data overrun."

3.7. Special Considerations When Using IEEE488 Interfacing

There are several differences between the **IEEE488** and **RS232** interface operation, these are all due to the extended capabilities of the hardware interface of the IEEE488 standard.

3.7.1 Bus Timing

Almost all of the timing requirements of the bus interface are handled by the hardware handshake system used by the IEEE488 interface. During decode of a command all further received data are "held-off" by this hardware handshake until the decode has been completed. Typically data transfer rates of up to 50,000 characters per second are attainable with the **2501/2/3AH**.

3.7.2 Bus Commands

As previously mentioned, the IEEE488 interface can perform many tasks that the RS232 does not, those used by the **2501/2/3AH** are as follows -

Remote/Local. This has been previously described.

Device Clear. The IEEE488 defined Device Clear functions (both selective and global) force the **2501/2/3AH** to perform a power-on reset function.

Interface Clear. The IEEE488 standard defines this command, which causes the interface portion of the **2501/2/3AH** to be reset to the power on conditions, aborting any bus activity in progress.

3.7.3 Other IEEE488 Specific Items

Should a handshake sequence be improperly completed during a transfer of data to or from the **IEEE488** interface, then the **2501/2/3AH** will automatically perform a power on reset sequence. This facility prevents the interface becoming "locked out" should the interface cable be removed or become faulty during a data transfer.

3.8. Command Set

The various features of the **2501/2/3AH** may be controlled by the controller sending certain command "strings" to the **2501/2/3AH**. The user may freely distribute "space" and non-printing characters between commands throughout the command string, and may send more than one command before sending the termination character.

Commands are terminated by the reception of a "line feed", the reception of a character with the EOI line asserted, or by the reception of the "Group Execute Trigger" command.

The user may freely use either lower or upper case characters, as desired.

The list of commands shown here are for software versions up to and including main software version 2.01. Future software revisions may include more capabilities.

The commands listed below are shown in alpha-numeric order, the upper-case portion of the command is the actual command operator, the lower case portion(s) of the command represents the optional parameter(s) for the command. These optional portions of the commands are denoted as follows :

[c] This shows that the command affects a specific channel. If this optional portion is not included, then channel A is affected. If *[A]*, *[B]* or *[C]* is included then channel A, B or C respectively are affected. If the selected channel does not exist (e.g., specifying *[C]* to a **2501**), then channel A is affected.

parameter This shows that the user should place the required parameter descriptor in the specified position. The user is referred to the end of this section for a complete list of the available parameter descriptors and formats.

n An integer number having the specified range. In cases where more than one digit is possible, the user may optionally place the leading zero characters. This data may not have a preceding polarity sign character.

numeric A floating point number having the specified units. This data may have an optional preceding polarity character. The decimal point is optional, and may be in any desired position. "e" format numbers are also accepted.

string One of the specified possible character strings for the specific command.

3.8.1 ACCUM=string

This command controls the accumulation capabilities of the instrument. These commands (with the exception of the ***ACCUM=CLEAR*** command) are only actioned when the instrument has not been configured for rear panel control of accumulation.

ACCUM=ON This command both initiates an accumulation and clears any prior accumulation results.

ACCUM=OFF This command terminates an accumulation. Final results are available following a delay of one measurement period following the termination of the accumulation.

ACCUM=RESTART This command restarts an accumulation. This is similar to the '*ACCUM=ON*' command shown above, but does not clear any previously taken accumulated results.

ACCUM=CLEAR This command clears any accumulated results to their initial values (normally zero). This may be commanded during any phase of an accumulation, but is normally used while an accumulation is not being performed.

3.8.2 ANALOG[n]=DEFAULT, ANALOG[n]=parameter, ANALOG[n]=range/zero/span and ANALOG[n]=numeric

These commands are only effective if option **AN12** is fitted. These commands either force the specified (***n***, between 0 and 11 inclusive) analog output to the specified output level (***numeric***, -1.0 to +1.0 yielding an output level of between -fullscale and +fullscale respectively), or returns the analog output (***n***) to the parameter, zero offset and span specified by means of the front panel controlled configuration (*ANALOG[n]=DEFAULT*), or configures the specified analog output to the indicated range (*5V*, *10V*, or *5mA*), parameter zero offset (numeric value) and parameter span (numeric value), or sets the output level to be determined from the value of the passed parameter.

It should be noted that, following a power-on reset (or a device clear via the IEEE488 interface), all analog outputs are returned to their respective front panel configured parameters, channels, zero offsets and spans.

These commands allow the user to either override an analog output used to drive a plotter or alarm output, or allow the user to control another instrument or power supply via this analog level.

3.8.3 CIT[c]=numeric

This command specifies that the selected channel (channel A if the optional *[c]* portion is not present) is using a current output CT on its input that has an input to output ratio given in the numeric portion of the command. The = character is optional. If the specified channel was configured for voltage input measurement of current (i.e. an external CT or shunt) then this command deselects that mode, returning current measurement to the internal current shunt measurement mode.

3.8.4 CLRDISPLAY (software versions 2.00 and later only)

This command clears all display lines.

3.8.5 CLRUPTIME (software versions 2.00 and later only)

This command clears the timer which may be used to identify the exact time at which each channels' parametric data was last established (see the '*READ=*' commands' '*UPTIME[c]*' parameter).

3.8.6 CVT[c]=numeric

This command specifies that the selected channel (channel A if the optional *[c]* portion is not present) is using a voltage output CT or current shunt on its current input that has an input (amps) to output (volts) ratio given in the numeric portion of the command. The = character is optional.

3.8.7 DISP[n]=parameter (software versions 2.00 and later only)

This command specifies that the selected display line (***n***, 0 through 49 inclusive) will display the specified parameter. If the optional [n] portion is not specified, or specifies a line beyond the last defined line, then the first undefined line is affected. The = character is optional. See the list at the end of this section for the available parameter descriptors.

3.8.8 EQN[n]=name/parameter (option HIST software versions 2.01 and later only)

This command sets the specified equation number to the set name string and parameter definition, which may include an equation of up to 500 characters. The result of this equation may be used as a 'normal' parameter by reffering to it by its' name. Using a standard parameter name does NOT override the standard definition, but renders this equation definition as being invisible.

3.8.9 EXTCAL, EXTSKIP and EXTUSE (software versions 2.01 and later only)

These commands allow the user to perform an automated external calibration of the instrument. The ***EXTCAL*** command initiates an external calibration sequence, the ***EXTSKIP*** command selects the next external calibration point without affecting the data for the point being measured (if any) and the ***EXTUSE*** command shows that the instrument should compute the calibration data using the actual input level present and then select the next calibration point. The nominal input level required may be obtained by finding the current/voltage range in use for each channel using the ***READ=STATUS*** command (described later in this chapter).

3.8.10 FFT[c]=maxharm/bandwidth/type (software versions 2.00 and later only)

This command configures the FFT based harmonic analysis for the group containing the channel *[c]*, as defined by ***maxharm/bandwidth/type***. See also the ***FUND*** and ***HARM*** commands.

MAXHARM this integer defines the highest harmonic number which is to be made available, this overrides any requests for higher harmonics by individual parameter requests. Setting this to 0 disables FFT based harmonic analysis for this group.

BANDWIDTH this integer defines the ratio between the fundamental frequency and the bandwidth over which each harmonic is measured. Setting this to 0 disables FFT based harmonic analysis for this group.

TYPE this string may be either ***NORMAL*** or ***WINDOWED***.

3.8.11 FILT[c]=n or FILT[c]=numeric

This command sets the group containing the channel *[c]* as using a digital filter. The = character is optional. The available formats are as follows :

FILT[c]=0 No filtering.

FILT[c]=1 20KHz Low Pass Filter

FILT[c]=2 10KHz Low Pass Filter

FILT[c]=3 5KHz Low Pass Filter

FILT[c]=4 2KHz Low Pass Filter

FILT[c]=5 1KHz Low Pass Filter

FILT[c]=numeric Sets the low pass filter corner frequency to the passed numeric value, in Hz. A minimum value of 6Hz is allowed, a value in excess of 200KHz yields a 5MHz filter.

3.8.12 FMEAS[i]=min/max/period/filter (software versions 2.00 and later only)

This command sets the measurement of frequency for the input ***[i]*** as being performed over the frequency range from ***min*** to ***max*** numeric value frequencies (in Hz), over the ***period*** numeric value (in seconds) and using optional result filtering (***0*** = none, ***1*** = fast, ***2*** = medium, ***3*** = slow). If the specified input is enabled as a synchronization source for establishing the fundamental frequency of one or more groups of channels then this sets all affected input measurements to these values, and sets the minimum expected frequency for these group(s) (for downranging purposes, see also the *RANGETIME* command) to the value specified by ***min***. The input may be specified by the strings ***CHAV***, ***CHAI***, ***CHBV*** etc..

3.8.13 FUND[c]=string (software versions 2.00 and later only)

This command sets the group containing the channel ***[c]*** as having its' fundamental frequency defined by ***string***. Valid ***string*** contents are as follows -

chlist/inlist/ multiplier

the fundamental frequency is established from the channel(s) listed in the string ***chlist*** (e.g. ***ABC***), using the input(s) listed in the string ***inlist*** (e.g. ***VI***), using an optional ***multiplier*** numeric quantity. The channels specified must either all be members of the group to which the [c] channel belongs, or a single non-member channel.

numeric the fundamental frequency is set to the fixed value set by the ***numeric*** value (in Hz).

3.8.14 GROUPS=list,list,list (software versions 2.00 and later only)

This command sets the channels indicated by their channel letter being included in the list string, as being contained in the three synchronous measurement groups respectively. Each channel MUST BE included in a list, and MAY NOT be included in more than one list.

3.8.15 GRPIO[c]=string (software versions 2.00 and later only)

This command sets the group containing the channel *[c]* as having the input/output type defined by *string*. Valid string contents are as follows -

IN the group is measuring input power

OUT the group is measuring output power

AUX the group is measuring neither input or output power

3.8.16 GRPTYPE[c]=string (software versions 2.00 and later only)

This command sets the group containing the channel *[c]* as having the grouping type defined by *string*. Valid string contents are as follows -

NORM	no special operations are performed when calculating the totals for this group.
3P3W or DELTA	The group is assumed to be measuring a 3-phase 3-wire power line and special calculations are performed for combining the measured data to produce total values.
3P4W or WYE	The group is assumed to be measuring a 3-phase 4-wire power line and special calculations are performed for combining the measured data to produce total values.
OFF	All channels within the group are disabled.

3.8.17 HARM[c]=string (software versions 2.00 and later only)

This command sets the group containing the channel ***[c]*** as measuring harmonic signal content as defined by *string*. See also the ***FFT*** and ***FUND*** commands. Valid string contents are as follows -

OFF	no harmonic analysis is performed within the group. The *FFT* command has no affect with this setting.
SINGLE	a single harmonic analysis is performed within the group during each amplitude measurement period.
NORM	harmonic analysis is performed within the group, with multiple analyses being averaged during the measurement period as necessary to encompass the entire period.
IEC555.2	IEC555.2 compliant harmonic analysis is performed within the group. The *FFT* command has no affect with this setting.

3.8.18 HOLD

This command specifies that the instrument is to enter the HOLD state. All database parameters are maintained at the values present at the time this command is received. These parameters may be subsequently released by the ***RUN*** command. This command is only effective if the rear panel control input has not been configured for control of this function.

3.8.19 INPHASE=list (software versions 2.01 and later only)

This command specifies which channels (defined by *list*) are connected in-phase when configured as measuring 3-phase 3-wire power. All channels should be within the same group, any remaining

channels within the group which are not contained within *list* are assumed to be connected in anti-phase.

3.8.20 INPUTCAL (software versions 2.01 and later only)

This command specifies that the instrument is to perform an automatically sequenced input calibration sequence. The input terminal pairs should each be shorted together prior to issuing this command.

3.8.21 INTCAL (software versions 2.01 and later only)

This command specifies that the instrument is to perform an automatically sequenced internal calibration sequence.

3.8.22 IRNG[c]=string

This command specifies that the instrument is to select the specified range for use on the specified channel. If the channel is not specified (i.e., the *[c]* portion is not included) then channel A is affected by this command. The = character is optional. The available strings are as shown below :

IRNG[c]=20A	Selects the 20A (internal current shunt) range.
IRNG[c]=10A	Selects the 10A (internal current shunt) range
IRNG[c]=5A	Selects the 5A (internal current shunt) range.
IRNG[c]=2A	Selects the 2A (internal current shunt) range.
IRNG[c]=1A	Selects the 1A (internal current shunt) range.
IRNG[c]=0.5A	Selects the 0.5A (internal current shunt) range.
IRNG[c]=0.2A	Selects the 0.2A (internal current shunt) range.
IRNG[c]=0.1A	Selects the 0.1A (internal current shunt) range.
IRNG[c]=0.05A	Selects the 0.05A (internal current shunt) range.
IRNG[c]=IAUTO	Selects the current input, using internal current shunts, in autorange.
IRNG[c]=5V	Selects the 5V (using current bypass) range.
IRNG[c]=2.5V	Selects the 2.5V (using current bypass) range.

IRNG[c]=1V Selects the 1V (using current bypass) range.

IRNG[c]=0.5V Selects the 0.5V (using current bypass) range.

IRNG[c]=0.25V Selects the 0.25V (using current bypass) range.

IRNG[c]=0.125V Selects the 0.125V (using current bypass) range.

IRNG[c]=0.05V Selects the 0.05V (using current bypass) range.

IRNG[c]=0.025V Selects the 0.025V (using current bypass) range.

IRNG[c]=0.01V Selects the 0.01V (using current bypass) range.

IRNG[c]=VAUTO Selects the current input, using current bypass input, in autorange.

IRNG[c]=40AH Selects the 40A (using internal Hall Effect CT) range.

IRNG[c]=20AH Selects the 20A (using internal Hall Effect CT) range.

IRNG[c]=10AH Selects the 10A (using internal Hall Effect CT) range.

IRNG[c]=5AH Selects the 5A (using internal Hall Effect CT) range.

IRNG[c]=HAUTO Selects the internal Hall Effect CT, in autorange.

3.8.23 MEAS[c]=numeric

This command specifies that the selected channel should use the specified measurement period (in seconds). If the channel is not specified (i.e., the *[c]* portion is not included) then channel A is affected. The numeric portion may be between 0.001 and 10000.0 inclusive, values outside this range will be set to the closest allowable value. Setting any channel within a defined group will automatically change all channels within the defined group.

3.8.24 NOCT[c]

This command specifies that the selected channel does not have a CT connected on its current input. If the *[c]* portion is not present, then channel A is affected by this command. If the specified channel was configured for voltage input measurement of current (i.e. an external CT or shunt) then this command deselects that mode, returning current measurement to the internal current shunt measurement mode.

3.8.25 NOPT[c]

This command specifies that the selected channel does not have a PT connected on its voltage input. If the *[c]* portion is not present, then channel A is affected by this command.

3.8.26 PRINT=n (software versions 2.01 and later only)

This command initiates a printout, using the default printer device, having the defined format number. Formats 0 through 9 are factory defined (see the printout section for details), while formats 10 through 19 are user defined. If the specified printout format is undefined, or no printer device is configured, then no action is taken.

3.8.27 PT[c]=numeric

This command specifies that the selected channel (channel A if the optional *[c]* portion is not present) is using a PT on its input that has an input to output ratio given in the numeric portion of the command. The = character is optional.

3.8.28 RANGETIME[c]=numeric (software versions 2.00 and later only)

This command sets the group containing the channel *[c]* as having minimum downrange timing set by the numeric value (in seconds). This value is only utilized if it is more than 1/2 of a period of the minimum defined fundamental frequency for the group.

3.8.29 READ=parameter

This command determines which parameter(s) the instrument will next transmit to the controller. For the **RS232** interface the requested data will be transmitted automatically following decode of this command, whereas the **IEEE488** will simply store this request until the instrument is next interrogated by the controller (i.e. addressed as a talker).

Several parameters (up to a maximum of 30) may be specified to be read simultaneously, if desired, with a maximum response string length of 1000 characters. Here, each ***parameter*** should be separated by the **:** (colon) character. If this is commanded, then each data item read will be separated by the **,** (comma) character in the received data string.

3.8.30 RECALL=n

This command specifies that the instrument should reset the configuration to that contained in the specified storage location. The number ***n*** should be between 0 and 65535. The user should note that this also sets which saved configuration will be retrieved following a reset of the instrument. Attempting to recall configuration from an undefined store location has no affect on the configuration of the instrument.

3.8.31 RESYNC[c] and RESYNC (software versions 2.00 and later only)

These commands allow the user to resynchronize reads of parameters to accomodate changes in the input waveforms. The RESYNC[c] form of this command affects only the specified channel, and those within the same synchronuous group, while the RESYNC form affects all channels within the instrument. This command has no affect if the instrument is presently in the HOLD state.

The overall affect of implementing this command is as follows :

Any measurement in progress is aborted and a new measurement is initiated immediately following any settling delay imposed by input filtering requirements.

Any attempts to read data from the instrument will be "unavailable" until the next measurement is completed.

3.8.32 RUN

This command releases a previously received ***HOLD*** command. If the instrument is not presently in the HOLD state then this command has no effect. This command is only effective if the rear panel control input has not been configured for control of this function.

3.8.33 SAVE=n/string

This command specifies that the instrument should save the present configuration in the specified storage location. The number ***n*** should be between 0 and 65535. The user should note that this also sets which saved configuration will be retrieved following a reset of the instrument. The command may optionally contain a name *string* (up to 12 characters in length) which is used to name the specified storage location. In software versions prior to 2.00 the naming option is unavailable.

3.8.34 SWITCH=string/string

This command allows the user to reconfigure the rear panel control input. The user should note that the configuration is one of the items stored in the configuration storage areas of the instrument, thus this configuration will be overridden by either an instrument reset or a recall operation.

The first string defines the operation to be controlled by the reap panel control input, the available options being as follows :

OFF	This turns off the rear panel control input, leaving the accumulation and run/hold functions available for control by the interface or front panel.
ACCUM	This configures the rear panel control input to control the accumulation function of the instrument. This stops this function being controlled by either the interface or front panel of the instrument.
RUN	This configures the rear panel control input to control the run/hold function of the instrument. This stops this function being controlled by either the interface or front panel of the instrument.

The second string indicates the 'active' state of the rear panel control input. If the first string indicated *OFF*, then this second string is optional (and is ignored if present). The separating '/' character is optional.

OPEN This configures the rear panel control input such that the desired operation is performed while the input is in the open or logic '1' state.

CLOSED This configures the rear panel control input such that the desired operation is performed while the input is in the closed or logic '0' state.

3.8.35 VRNG[c]=string

This command specifies that the selected channel (channel A if the ***[c]*** portion is omitted) sets its' voltage range to that specified by the ***string*** portion of the command. The available options for the ***string*** portion are as follows :

VRNG[c]=1200V Selects the 1200V range.

VRNG[c]=600V Selects the 600V range.

VRNG[c]=300V Selects the 300V range.

VRNG[c]=150V Selects the 150V range.

VRNG[c]=60V Selects the 60V range

VRNG[c]=30V Selects the 30V range.

VRNG[c]=15V Selects the 15V range.

VRNG[c]=AUTO Selects autorange.

3.8.36 @

This character command is used in the RS232 interface to cause the results of a previously defined set of parameter data requests (i.e. ***READ=parameter*** command) to be resent with the latest available data.

3.9. Available *parameter* strings

The ***DISP*** and ***READ*** commands accept any of these strings as defining the data to be interrogated by these commands.

3.9.1 2501/2/3 Compatibility Format (*READ*= only)

The general format for type of parameter definition is ***chl/parameter.*** These format strings are converted to the 'native' **2501/2/3AH** format internally, with no units conversions, deviations or filtering.

The ***chl/*** portion of the string is optional, and specifies the source of the parameter. If this portion is omitted then channel A is used as the source. The available options for this portion of the string are as follows :

CHA/	Channel A data is the source.
CHB/	Channel B data is the source. This option is not available in the **2501AH**, if specified then the command has no affect.
CHC/	Channel C data is the source. This option is not available in the **2501AH**, and **2502AH**, if specified then the command has no affect.
GROUP/	The total of all channels in the same group as channel A is the source.
INPUT/	The total of all channels defined as measuring the input.
OUTPUT/	The total of all channels defined as measuring the output.

The available ***parameter*** selections are as follows :

ACAHR	The AC coupled Ampere-Hour accumulated data. Only channels A, B or C are valid sources for this parameter.
ACEPA	The AC coupled computed Effective Phase Angle data (i.e., $\cos^{-1}$ (***ACPF***)).
ACI	The AC coupled current data.
ACPF	The AC coupled Power Factor data.
ACVAHR	The AC coupled VA-Hour accumulated data.
ACVA	The AC coupled VA data.
ACV	The AC coupled voltage data.
ACWHR	The AC coupled Watt-Hour accumulated data.
ACW	The AC coupled power data.
AHR	The AC+DC coupled Ampere-Hour accumulated data. Only channels A, B or C are valid sources for this parameter.
ATHD	The computed current total harmonic distortion. Only channels A, B or C are valid sources for this parameter.
DCAHR	

The DC coupled Ampere-Hour accumulated data. Only channels A, B or C are valid sources for this parameter.

DCI The DC coupled current data.

DCVAHR The DC coupled VA-Hour accumulated data.

DCVA The DC coupled VA data.

DCV The DC coupled voltage data.

DCWHR The DC coupled Watt-Hour accumulated data. It should be noted that this is the same as the ***DCVAHR*** parameter.

DCW The DC coupled power data. Is should be noted that this is the same as the ***DCVA*** parameter.

EFF The Efficiency data. This data is the ratio of the ***OUTPUT/PWR*** and ***INPUT/PWR*** parameters expressed as a percentage. If a source is specified it will be ignored, as this parameter has no specific data source.

EPA The AC+DC coupled computed Effective Phase Angle data (i.e., $\cos^{-1}$ (***PF***)).

FREQ The fundamental frequency of the voltage or current input (in Hz). Only channels A, B or C are valid sources for this parameter.

ICF The Current Crest Factor data. Only channels A, B or C are valid sources for this parameter.

IFF The Current Form Factor data. Only channels A, B or C are valid sources for this parameter. This is only available in main software versions 2.00 and later.

LOSS The Power Loss data. This data is the result of subtracting the ***OUTPUT/PWR*** data from the ***INPUT/PWR*** data. If a source is specified it will be ignored, as this parameter has no specific data source.

MODI The Mean Modulus Current data. This is only available in main software versions 2.00 and later.

MODV The Mean Modulus Voltage data. This is only available in main software versions 2.00 and later.

PF The AC+DC coupled Power Factor data.

PKI The Peak current data. Only channels A, B or C are valid sources for this parameter.

PKV The Peak voltage data. Only channels A, B or C are valid sources for this parameter.

PKW The Peak power data. Only channels A, B or C are valid sources for this parameter.

PWR The AC+DC coupled power data.

RMSI The AC+DC coupled current data.

RMSV The AC+DC coupled voltage data.

VAHR The AC+DC coupled VA-Hour accumulated data.

VARHR The VAR-Hour accumulated data.

VAR The VAR data.

VA The AC+DC coupled VA data.

VCF The Voltage Crest Factor data. Only channels A, B or C are valid sources for this parameter.

VFF The Voltage Form Factor data. Only channels A, B or C are valid sources for this parameter. This is only available in main software versions 2.00 and later.

VTHD The computed voltage total harmonic distortion. Only channels A, B or C are valid sources for this parameter.

WHR The AC+DC coupled Watt-Hour accumulated data.

3.9.2 Full Parameter Definition Format

This is the recommended format for defining parameters in the 2501/2/3AH instruments where compatibility with earlier instruments is not required. This format allows for complete definition of parameters with optional units conversions, filtering and deviation computation and limits checking. This format also allows for access to 'special' parameters which have textual results rather than numerical.

The general format for this style is :

parameter[source and bandwidth]{sub-definition string}

or

special-parameter

where :

parameter is a string defining the parameter

source and bandwidth is a series of strings or numeric data defining the source and bandwidth for the parameter, this string is surrounded by *[* and *]* characters.

sub-definition string is an optional string containing optional additional operations to be performed on the parameter result. If no further processing is required, then the surrounding *{* and *}* characters need not be present.

special-parameter is a special parameter definition string defining the special (textual) data to be retrieved.

The available formats for each portion is as follows -

parameter string contains one of the following strings, defining the 'base' parameter to be retrieved, the source and bandwidth of which is defined by the *source and bandwidth* -

AMPL The RMS amplitude (i.e. Volts or Current). This parameter requires a single input source and either a string bandwidth or a pair of integers defining the harmonic range for the data. The default units for these results is Vrms or Arms as applicable.

AMPLFR The RMS amplitude (i.e. Volts or Current). This parameter requires a single input source and a pair of numeric frequencies defining the center frequency and half-bandwidth for the data (in Hz). (Note that this data is not available from the front panel). The default units for these results is Vrms or Arms as applicable.

AMPLHR The accumulated RMS amplitude (i.e. VHr or AHr). This parameter requires a single input source and a string bandwidth. The default units for these results is V.Hr or A.Hr as applicable.

AVG The average rectified amplitude (i.e. Volts or Current). This parameter requires a single input source. The default units for these results is V or A as applicable.

CHARGE The accumulated DC coupled positive RMS amplitude (i.e. VHr or AHr). This parameter requires a single input source. The default units for these results is V.Hr or A.Hr as applicable. This parameter is only available from main software versions 2.00 and later.

CORREL Power Factor or Correlation (i.e. W/VA). This parameter requires a channel or group of channels, and either a string bandwidth or a pair of integers defining the harmonic range for the data. The default units for this result is none.

CF Crest Factor (i.e. Peak/RMS Volts or Current). This parameter requires a single input source and a string bandwidth. The default units for this result is none.

DISCHRGE The accumulated DC coupled negative RMS amplitude (i.e. VHr or AHr). This parameter requires a single input source. The default units for these results is V.Hr or A.Hr as applicable. This parameter is only available from main software versions 2.00 and later.

DPF Dissipation or Displacement Power Factor (i.e. W/VA at the fundamental frequency only). This parameter requires a channel or group of channels. The default units for this result is none.

DTOY The Voltage between a calculated neutral and a phase of a Delta connected 3-phase supply. This parameter requires a channel. The default units for this result is Vrms.

EFF Efficiency (i.e. Wout/Win). This requires no further definition. The default units for this result is none (i.e. a pure ratio).

EPA The inverse cosine of Power Factor. This parameter requires a channel or group of channels, and either a string bandwidth or a pair of integers defining the harmonic range for the data. The default units for this result is radians.

ETRIPL Total even order triplens (Volts or Current). This parameter requires a single input source and a single integer defining the highest harmonic to include in the summation. The default units for these results is Vrms or Arms as applicable.

FF Form Factor (i.e. RMS/Average Rectified Voltage or Current). This parameter requires a single input source. The default units for this result is none.

FREQ Frequency. This parameter requires either a single input source, or a single channel source and an optional single integer harmonic number. The default units for this result is Hz.

GAIN The Gain or ratio between any two signals. This parameter requires a single input source and single integer harmonic (dividend), and a single reference source and single integer harmonic (divisor). The default units for this result is none (i.e. a pure ratio).

GAINI The imaginary portion of *GAIN* (see above, *GAIN* = *GAINR* + j.*GAINI*). Both inputs should belong to channels within the same group for the result to be meaningful. The default units for this result is none (i.e. a pure ratio).

GAINR The real portion of *GAIN* (see above, *GAIN* = *GAINR* + j.*GAINI*). Both inputs should belong to channels within the same group for the result to be meaningful. The default units for this result is none (i.e. a pure ratio).

HIGH The highest positive excursion of a signal (Volts or Current). This parameter requires a single input source. The default units for these results is Vpk or Apk as applicable.

HIGHEST The largest value for *HIGH* (see above) obtained during an accumulation. The default units for these results is Vpk or Apk as applicable.

HZ Frequency (alternative for *FREQ* above).

IMAG The quadrature portion of a signal (Volts or Current). This parameter requires a single input source and single integer harmonic, and a single reference source and single integer harmonic. Both inputs should belong to channels within the same group for the result to be meaningful. The default units for these results is Vrms or Arms as applicable.

IMP The load impedance (i.e. Volts/Current). This parameter requires a channel and either a string bandwidth or a pair of integers defining the harmonic range for the data. The default units for this result is ohms.

INPHS The In-Phase portion of a signal (Volts or Current). This parameter requires a single input source and single integer harmonic, and a single reference source and single integer harmonic. Both inputs should belong to channels within the same group for the result to be meaningful. The default units for these results is Vrms or Arms as applicable.

INRUSH The highest excursion from zero since last cleared (Volts or Current). This parameter requires a single input source. The default units for these results is Vpk or Apk as applicable.

KFACT The K-Factor (Volts or Current). This parameter requires a single input source and a single integer defining the highest harmonic to include in the summation. The default units for this result is none.

KF An alternate for *KFACT* (see above).

LOSS Power Loss (i.e. Win - Wout). This requires no further definition. The default units for this result is W.

LOW The highest negative excursion of a signal (Volts or Current). This parameter requires a single input source. The default units for these results is Vpk or Apk as applicable.

LOWEST The largest value for *LOW* (see above) obtained during an accumulation. The default units for these results is Vpk or Apk as applicable.

MAXPK The largest absolute value of *HIGHEST* or *LOWEST* (see above).

OTRIPL Total odd order triplens (Volts or Current). This parameter requires a single input source and a single integer defining the highest harmonic to include in the summation. The default units for these results is Vrms or Arms as applicable.

PEAK The largest absolute value of *HIGH* or *LOW* (see above).

PF An alternate for *CORREL* (see above).

PHASE The Phase between two signals. This parameter requires a single input source and single integer harmonic, and a single reference source and single integer harmonic. Both inputs should belong to channels within the same group for the result to be meaningful. The default units for this result is radians.

PHS An alternate for *PHASE* (see above).

PKPK The difference between *HIGH* and *LOW* (see above).

PKVA The highest recorded absolute value of instantaneous VA. This parameter requires a single channel source. The default units for this result is VApk.

PK An alternate for *PEAK* (see above).

PWR True Power. This parameter requires a channel or group of channels and either a string bandwidth or a pair of integers defining the harmonic range for the data. The default units for this result is W.

QUAD An alternate for *IMAG* (see above).

R The load resistance (i.e. in-phase Volts/Current, $IMP = R + j.X$). This parameter requires a channel and either a string bandwidth or a pair of integers defining the harmonic range for the data. The default units for this result is ohms.

RATIO An alternate for *GAIN* (see above).

RATIOI An alternate for *GAINI* (see above).

RATIOR An alternate for *GAINR* (see above).

REAL An alternate for *INPHS* (see above).

REA The load reactance (i.e. quadrature Volts/Current, $IMP = R + j.REA$). This parameter requires a channel and either a string bandwidth or a pair of integers defining the harmonic range for the data. The default units for this result is ohms.

RECTIFY An alternate for *AVG* (see above).

RES An alternate for *R* (see above).

RMS An alternate for *AMPL* (see above).

SPAMPL The signal amplitude measured at the specified spectrum point for the specified single input. The default units for these results is Vrms or Arms as applicable.

SPFREQ The frequency associated with the specified spectrum point for the specified single input or channel. The default units for this result is Hz.

THDF The Total Harmonic Distortion of the selected signal (Volts or Current), relative to its fundamental component. This parameter requires a single input source and a single integer defining the highest harmonic to include in the summation. The default units for this result is none (i.e. a pure ratio).

THDH The Total Harmonic Distortion of the selected signal (Volts or Current), relative to its total harmonic content. This parameter requires a single input source and a single integer defining the highest harmonic to include in the summations. The default units for this result is none (i.e. a pure ratio).

THDT The Total Harmonic Distortion of the selected signal (Volts or Current), relative to its total RMS content. This parameter requires a single input source and a single integer defining the highest harmonic to include in the summation. The default units for this result is none (i.e. a pure ratio).

TRIPL Total triplens (Volts or Current). This parameter requires a single input source and a single integer defining the highest harmonic to include in the summation. The default units for these results is Vrms or Arms as applicable.

VAHR The accumulated VA.Hr. This parameter requires a channel or group of channels and a string bandwidth. The default units for this result is VA.Hr.

VARHR The accumulated VAR.Hr. This parameter requires a channel or group of channels. The default units for this result is VAR.Hr.

VAR Reactive or Imaginary Power. This parameter requires a channel or group of channels and either a string bandwidth or a pair of integers defining the harmonic range for the data. The default units for this result is VAR.

VA Apparent Power. This parameter requires a channel or group of channels and either a string bandwidth or a pair of integers defining the harmonic range for the data. The default units for this result is VA.

WATTS An alternate for *PWR* (see above).

WHR The accumulated W.Hr. This parameter requires a channel or group of channels and a string bandwidth. The default units for this result is W.Hr.

X An alternate for *REA* (see above).

YTOD The Voltage between two phases of a Wye connected 3-phase supply. This parameter requires a channel or group of channels. The default units for this result is Vrms.

Z An alternate for *IMP* (see above).

source and bandwidth strings contain one or more of the following strings seperated by commas -

A The Voltage input of channel A (included for compatibility with future Xitron products).

B The Current input of channel A (included for compatibility with future Xitron products).

C The Voltage input of channel B (included for compatibility with future Xitron products).

D The Current input of channel B (included for compatibility with future Xitron products).

E The Voltage input of channel C (included for compatibility with future Xitron products).

F The Current input of channel C (included for compatibility with future Xitron products).

R or S Alternates for *F* (see above).

CHAV The Voltage input of channel A.

CHAI The Current input of channel A.

CHBV The Voltage input of channel B.

CHBI The Current input of channel B.

CHCV The Voltage input of channel C.

CHCI The Current input of channel C.

AB Channel A (included for compatibility with future Xitron products).

CD Channel B (included for compatibility with future Xitron products).

EF Channel C (included for compatibility with future Xitron products).

CHA Channel A.

CHB Channel B.

CHC Channel C.

G, GRP or GROUP The group of channels including channel A.

GA, GRPA or GROUPA The group of channels including channel A.

GB, GRPB or GROUP The group of channels including channel B.

GC, GRPC or GROUPC The group of channels including channel C.

I, IN or INPUT The total of all channels defined as measuring input power.

O, OUT or OUTPUT The total of all channels defined as measuring output power.

DC The DC component only of a parameter.

AC The AC component only of a parameter.

ACDC or DCAC The DC and AC components (i.e. the total) of a parameter.

AC+DC or DC+AC The DC and AC components (i.e. the total) of a parameter.

integer A harmonic in the range 0 through 2047.

sub-definition strings contain one or more of the following strings separated by semi-colons -

FILTER=numeric Sets that this parameter result is to be filtered with the set numeric time constant (in seconds).

UNITS=string Sets that the resultant units for the parameter are to be those specified by *string*. See a later section for available units strings.

NOMINAL=parameter[source and bandwidth]

Sets that the nominal or reference value of this parameter is the value of the set parameter with its' associated source and bandwidth.

NOMINAL=numeric Sets that the nominal or reference value of this parameter is the value of the *numeric*.

NOMINAL@parameter[source and bandwidth]

Sets that the nominal or reference value of this parameter is the value of the set parameter with its' associated source and bandwidth, this value being established at the time that this string is decoded.

DELTA Sets that the difference between the parameter and the reference or nominal value is to be obtained. A *nominal* string must be present. Only one of *DELTA*, *RATIO*, *DELTAR* or *LIMIT* formats may be used for a single parameter.

RATIO Sets that the ratio between the parameter and the reference or nominal value is to be obtained. A *nominal* string must be present. Only one of *DELTA*, *RATIO*, *DELTAR* or *LIMIT* formats may be used for a single parameter.

DELTAR Sets that the ratio between the difference between the parameter and the reference or nominal value, and the nominal value, is to be obtained. A *nominal* string must be present. Only one of *DELTA*, *RATIO*, *DELTAR* or *LIMIT* formats may be used for a single parameter.

LIMIT=numeric Sets the maximum allowable deviation from the reference or nominal value. The string *HIGH*, *PASS* or *LOW* is returned instead of the value of the parameter. Only one of *DELTA*, *RATIO*, *DELTAR* or *LIMIT* formats may be used for a single parameter.

special-parameter strings are available as follows -

BLANK (*DISP[n]*= only) defines a blank ("--") display line. This parameter is only available from main software versions 2.00 and later.

DELETE (*DISP[n]*= only) defines that the display line is to be deleted, the 'gap' caused by this is 'closed' up by shifting all lower display lines upwards. This parameter is only available from main software versions 2.00 and later.

STATUS[c] defines that a string indicating the range, mode and overload status of each input within the channel defined by *c* (*A*, *B* or *C*) will be returned. The format of the data returned is shown later in this document. This parameter is only available from main software versions 2.00 and later.

DATE defines that the date (in the format set by the SYSTEM menu entry) will be returned.

TIMEDATE defines that the time and date (in the formats set by the SYSTEM menu entry, seperated by a single space character) will be returned.

TIME defines that the time (in the format set by the SYSTEM menu entry) will be returned.

ACCTIME defines that the number of seconds (to within the nearest millisecond) which the accumulation has been running will be returned.

UPTIME[c] defines that the number of seconds (to within the nearest millisecond) at which the selected channels' measurement data was last updated will be returned. This data may be reset to zero at any time by the ***CLRUPTIME*** command (this command clears all channels' timers simultaneously). This parameter is only available from main software versions 2.00 and later.

DUMP[n] (*READ=* only) defines that the contents of the memory location defined by the numeric *[n]* are to be read from the instrument. The string returned consists of a series of command strings in a format suitable for sending back to the instrument to return it to the settings contained in the specified memory location. If no memory location is specified (i.e., *[n]* is not specified) then the present settings of the instrument are returned. This parameter is only available from main software versions 2.01 and later.

ID (*READ=* only) defines that a string defining the instrument and software revisions are to be returned. The format of the data returned is shown later in this document. This parameter is only available from main software versions 2.00 and later.

3.9.3 Mathematical operators for HIST option

Instruments having one of the Co-Processor options fitted (options HIST0, HIST1, HIST2 or HIST4) may define an equation based on these parameter definitions and the following mathematical operators. The same *sub-definition strings* as those shown above may be applied following the equation string. The caption ..... indicates that any sub-expression may be present in the indicated position, in all cases (except as specifically noted) this sub-expression may contain any valid equation.

..... && ..... The AND conditional operator (used in conditional expressions only).

(.....) Defines a sub-expression.

..... * ..... The multiplication operator.

..... + ... The addition operator.

..... - ..... The subtraction operator.

..... / ..... The division operator.

..... <= ..... The 'less than or equal to' relational operator (used in conditional expressions only).

..... < ..... The 'less than' relational operator (used in conditional expressions only).

..... =< ..... The 'less than or equal to' relational operator (used in conditional expressions only).

..... == ..... The 'equal to' relational operator (used in conditional expressions only).

..... => ..... The 'greater than or equal to' relational operator (used in conditional expressions only).

.....> = ... The 'greater than or equal to' relational operator (used in conditional expressions only).

.....> ..... The 'greater than' relational operator (used in conditional expressions only).

ABS (.....) The absolute value unary function.

ACOS (.....) The inverse cosine unary function (returns value in radians).

..... *AND* ..... The AND conditional operator (used in conditional expressions only).

ASIN (.....) The inverse sine unary function (returns value in radians).

ATAN (.....) The inverse tangent unary function (returns value in radians).

COS (.....) The cosine unary function (takes a value in radians).

DERIV (.....) The rate of change unary function (returns value in units per second).

IF .... THEN .... ELSE .... The conditional operator construct (may include nested conditional constructs).

..... *EQU* ..... The 'equal to' relational operator (used in conditional expressions only).

E The constant e.

..... *GTE* ..... The 'greater than or equal to' relational operator (used in conditional expressions only).

..... *GT* ..... The 'greater than' relational operator (used in conditional expressions only).

INTEG (.....) The integration unary function (returns value in units.seconds).

LGT (.....) The base 10 logarithm unary function.

LN (.....) The base e logarithm unary function.

LOG10 (.....) The base 10 logarithm unary function.

LOG (.....) The base 10 logarithm unary function.

..... *LTE* ..... The 'less than or equal to' relational operator (used in conditional expressions only).

..... *LT* ..... The 'less than' relational operator (used in conditional expressions only).

MAX (.....) The highest value unary function (controlled as an accumulation variable).

MEAN (.....) The mean value unary function (controlled as an accumulation variable).

MIN (.....) The lowest value unary function (controlled as an accumulation variable).

..... OR ..... The OR conditional operator (used in conditional expressions only).

PI The constant pi.

SIN (.....) The sine unary function (takes a value in radians).

SQRT (.....) The square root unary function.

TAN (.....) The tangent unary function (takes a value in radians).

TOTAL (.....) The integration unary function (returns value in units.hours).

..... ^ ..... The exponentiation operator.

..... || ..... The OR conditional operator (used in conditional expressions only).

In many cases braces and multiplication operators may be implied. As examples ***SINPI*** is correctly interpreted as ***SIN(PI)*** and ***2PI*** is correctly interpreted as ***2*PI***. Normal operator precedence is used.

3.9.4 STATUS Data Format

READ=STATUS[c] returns data having a format dependant on the channel specification.

If no channel is specified (i.e. ***READ=STATUS***) then the returned data is as follows -

1st character The voltage range presently in use on channel A (0=1200V, 1=600V, 2=300V, 3=150V, 4=60V, 5=30V, 6=15V).

2nd & 3rd characters The current input and range presently in use on channel A (00=20A shunt, 01=10A shunt, 02=5A shunt, 03=2A shunt, 04=1A shunt, 05=0.5A shunt, 06=0.2A shunt, 07=0.1A shunt, 08=0.05A shunt, 10=5V bypass, 11=2.5V bypass, 12=1V bypass, 13=0.5V bypass, 14=0.25V bypass, 15=0.125V bypass, 16=0.05V bypass, 17=0.025V bypass, 18=0.01V bypass, 20=40A hall, 21=20A hall, 22=10A hall, 23=5A hall).

4th character The overload status of channel A voltage input (0=no overload, 1=overload).

5th character The overload status of channel A current input (0=no overload, 1=overload).

6th thru' 10th characters

As the 1st thru' 5th, but for channel B (all - characters if not fitted).

11th thru' 15th characters

As the 1st thru' 5th, but for channel C (all - characters if not fitted).

If a specific channel is specified (e.g. ***READ=STATUS[A]***) then only the data for that channel is returned (i.e. only 5 characters).

3.9.5 ID Data Format

READ=ID returns data having the following sub-strings, separated by comma characters - either ***2501AH***, ***2502AH*** or ***2503AH*** as applicable.

nn.nn main software revision.

nn.nn channel A supervisor DSP software revision (00.00 if not fitted).

nn.nn channel A amplitude DSP software revision (00.00 if not fitted).

nn.nn channel B supervisor DSP software revision (00.00 if not fitted).

nn.nn channel B amplitude DSP software revision (00.00 if not fitted).

nn.nn channel C supervisor DSP software revision (00.00 if not fitted).

nn.nn channel C amplitude DSP software revision (00.00 if not fitted).

nn.nn history co-processor software revision (00.00 if not fitted).

nn.nn analog I/O co-processor software revision (00.00 if not fitted).

nn.nn video co-processor software revision (00.00 if not fitted).

a special string allocated to any customer special software versions. This enables customer specific instruments to be recognized.

3.9.6 UNITS-string Format

UNITS=string within a ***sub-definition string*** should contain one of the following units definition strings available in the instrument. Not all parameters are compable with all units strings, wherever possible the instrument will attempt to convert the base parameter to the desired final units. Setting a unit does NOT change the bandwidth of the parameter, nor change the parameter itself. The strings shown below are case-sensitive.

a blank string is no units

A Amperes

Aac AC Amperes

Aavg Average, or Mean Rectified Amperes

Adc DC Amperes

Arms RMS Amperes

Apk Peak Amperes

Apkpk Peak to Peak Amperes

Aimag Imaginary Amperes

Areal Real Amperes

V Volts

Vac AC Volts

Vavg Average, or Mean Rectified Volts

Vdc DC Volts

Vrms RMS Volts

Vpk Peak Volts

Vpkpk Peak to Peak Volts

Vimag Imaginary Volts

Vreal Real Volts

dBV Voltage decibels relative to a 1V level

dBuV Voltage decibels relative to a 1%V level

AHr Ampere-Hours

VHr Volt-Hours

W Watts

Wac AC Watts

Wdc DC Watts

dBW Power decibels relative to a 1W level

dBmW Power decibels relative to a 1mW level

VA Volt-Amperes

VAac AC Volt-Amperes

VAdc DC Volt-Amperes

VApk Peak Volt-Amperes

VAR Reactive Power

VARac AC Reactive Power

HP Horse Power

WHr Watt-Hours

VAHr VA-Hours

VARHr VAR-Hours

% Percentage (ratio)

dB decibel (ratio)

deg degrees (180$ range)

deg360 degrees (0-360$ range)

grad grads

rad radians

pirad pi-radians (1 is equivalent to 180$)

Hz Hertz

cps Cycles-Per-Second

rpm Revolutions-Per-Minute

s seconds

Hr Hours

ohm Ohms

S Siemens

3.9.7 Examples of Full Parameter Definition Format Usage

This section shows some examples of full format parameter definitions. These may be used to define individual items to be interrogated via the interface (i.e. in a ***READ=*** command) or to define a display line (i.e. in a ***DISP[n]=*** command). In the case of the ***READ=*** command, multiple items may be defined for interrogation at the same time (up to 10 items) by separating each parameter definition by the : (colon) character.

AMPL[CHAV] Defines AC+DC RMS voltage on channel A.

AMPL[CHAV,DC] Defines DC only RMS voltage on channel A.

AMPL[CHAI,1,1] Defines fundamental only (harmonic #1) RMS current on channel A.

AMPL[CHCI,2,1000] Defines RMS current on channel C measured over the range of 2nd harmonic thru' the 1000th harmonic.

AMPLFR[CHAI,20e3,5e3] Defines RMS current on channel A measured over a range centered on 20KHz with a 5KHz bandwidth (i.e., 15-25KHz).

RATIO[CHAV,1,CHBV,1]

Defines the ratio between the fundamental voltage of channel A and the fundamental voltage of channel B.

THDF[CHAI,49]{UNITS=%}

Defines THD current (relative to fundamental) on channel A, measured up to and including the 49th harmonic, expressed in percentage units.

PWR[INPUT,ACDC]{FILTER=2.5}

Defines the total input power, including both AC and DC components, with a 2.5second single order filter applied to the result.

AMPL[CHAV,AC]{NOMINAL=AMPL[CHBV,AC];LIMIT=5.0;FILTER=2.00}

Defines a pass/fail check of the AC voltage of channel A, compared continuously against the AC voltage of channel B, allowing up to 5V difference before failing, and using a 2 second single order filter.

RATIO[CHAI,3,CHAI,1]{NOMINAL=0.0;LIMIT=0.2}

Defines a check of the ratio between 3rd harmonic and fundamental current of channel A, with a maximum limit of 20%.

3.10. High Speed Operation

The 2501/2/3AH family has the capability of operating at over 100 readings per second when correctly configured. This section covers some useful information regarding obtaining the highest possible speed from these instruments.

3.10.1 Measurement Periods

The highest possible reading rates are obtained when only those channels which are required to be high speed are configured with short measurement periods. Channels which are not required should either be turned off, or set to an amplitude measurement period in excess of 0.25 seconds. See the ***MEAS*** command for details.

3.10.2 Frequency Measurement

Inputs which are not configured for use for fundamental frequency determination should have their frequency measurement turned off. There is a significant speed improvement when the fundamental frequency range covers a range of less than 2:1. If harmonic measurements are not needed, or the

fundamental frequency is well known (to with 1%, e.g. line voltage), then the use of a fixed frequency fundamental will acheive significant results. See the ***FMEAS*** and ***FUND*** commands for details.

3.10.3 Harmonic Measurement

Harmonic measurements should only be enabled in groups of channels for which it is required. The maximum range of harmonics should be limited and the fundamental:bandwidth ratio kept to the default values if at all possible. If high frequencies are to be measured, then a significant improvement is speed can be realized by only allowing a single analysis per measurement period. See the ***HARM*** command for further details.

3.10.4 Interrogating Results

The user should read as many parameters at the same time as possible. This saves time in reducing the transmission of new READ= commands, and their decode in the instrument.

The amount displayed on the front panel should be reduced to as little as possible (less than four lines if possible) and any display line filters should be eliminated as these are continuously updated whether displayed or not.